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Macroeconomic and Financial Risk of South America

Marcela Guachamin

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Macroeconomic and Financial Risk of South America

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To my son Joaquín, the source of my inspiration and my force. Thanks for your love and support during the achievement of this dream.

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ABSTRACT

In the last years, the events of economic and financial turbulence in the world have increased the likelihood of spillover crises due to the vulnerability of economies and external shocks. In the case of South American countries, these countries have experienced long and short periods of economic and financial crises, caused by high levels of debt, combined with the depreciation of their currencies and the increase in inflation.

Identifying these periods of macroeconomic and financial vulnerability in South American countries will allow us to measure the level of uncertainty in order to promote macro-prudential strategies in the region. Therefore, the purpose of this dissertation is to identify, measure, evaluate contagion and monitor macro-financial risk of the South American region.

Before developing the empirical proposal, we performed a general literature review to analyze the concepts of macro-financial vulnerability, types of crises, contagion and stress tests with the purpose of understanding that macro-financial vulnerability should be monitored through the risk management process, using methods that identify the level of vulnerability, transmission links, evaluating impacts and determining uncertainty limits to promote macro-financial policies at the regional level in order to minimize risk exposure. Considering this, we conducted three empirical analyses using different methods to manage macroeconomic and financial risk at the regional level.

First, we build the macroeconomic- social-financial vulnerability index for 10 South American countries from 1978 to 2014 to measure the level of the uncertainty. This index is composed of macroeconomic, social development, liquidity, solvency and market vulnerability sub-indicators through the partial least squares structural equation model (PLS-SEM). We identify high (unmanageable, intolerable and unstable) and low (manageable, moderate, stable and strong) risk levels by an uncertainty regional thermometer, for this, we apply an early warning method, using three machine learning methods: (i) linear discriminant analysis (LDA), (ii) k-nearest neighbors (KNN) and (iii) support vector machines (SVMs). Our results are robust and consistent, because the macroeconomic-social-financial vulnerability index captures the periods of the crises of each country studied during this period.

Second, we evaluate the systemic contagion macro-financial risk in South America, for this, we examine if trade and financial globalization are drivers of macro-financial systemic transmission and detects if there is a macro-financial contagion risk through the interconnection of country's economic cycle synchronization, bilateral trade, and trade agreement linkages among 10 South American countries for the 1978-2014 period, using spatial econometric techniques. Our results are robust and find that both financial and trade globalization are channels of macro-financial transmission. Given that, an increase of financial openness led to the macro-financial risk also increases. On the other hand, when trade openness increases, the macro-financial risk decreases. Furthermore, we verify that the propagation of contagion derives from the three linkages analyzed by a cross-country dependency with macro-financial risk in the South American region.

Third, we monitor the systemic risk of the region by stress scenarios, which identify monetary and liquidity uncertainty in the face of macroeconomic shocks, considering high and low inflation regime and economic expansion and contraction regime, using the threshold vector autoregressive model (TVAR) non-linear model in South American countries for the period 2006Q1-2020Q2. Our main finding when the liquidity shock increase in Bolivia, Chile, Paraguay and Uruguay, also increase the low inflation regime. In the case of the liquidity shock on economic growth regime show different dynamics in each country. On the other hand, when monetary supply increases, the interest rate decreases in the short term for Argentina and Uruguay, but for Brazil in the long term. In the case of Ecuador and Paraguay in the short and medium term, when there is a monetary expansion, the interest rate increases, but there is not impact on inflation. Furthermore, Chile and Bolivia have a positive monetary shock on interest rate in the short and long term.

Keywords: macroeconomic-financial risk, early warning model, trade and financial globalization, spatial econometrics models, non-linear stress models and risk thresholds.

RÉSUMÉ

Depuis ces dernières années, les turbulences économiques et financières dans le monde ont augmenté la probabilité d'une propagation des crises en raison de la vulnérabilité des économies et des chocs externes. Dans le cas des pays d'Amérique du Sud, ils ont connu des périodes longues et courtes de crises économiques et financières, provoquées par le surendettement, combiné à une forte dépréciation de la monnaie et à une inflation croissante. L'identification de ces périodes de vulnérabilité macroéconomique et financière dans les pays d'Amérique du Sud nous permettra de mesurer le niveau d'incertitude afin de promouvoir des stratégies macro-prudentielles dans la région. Par conséquent, l'objectif de cette thèse est d'identifier, de mesurer, d'évaluer la contagion et de superviser le risque macro-financier dans la région sud-américaine. Avant de développer la proposition empirique, nous proposons une revue générale de la littérature pour évaluer les concepts de vulnérabilité macro-financière, les types de crises, la contagion et les tests de tension afin de comprendre que l'incertitude macro-financière doit être contrôlée par le processus de gestion du risque, en utilisant des méthodes qui identifient le niveau de vulnérabilité, les mécanismes de transmission, en évaluant les impacts et en identifiant les limites d'incertitude pour gérer les politiques macro-financières au niveau régional afin de minimiser l'exposition au risque. Dans cette optique, nous avons mené trois analyses empiriques utilisant différentes méthodes de gestion du risque macroéconomique et financier au niveau régional.

Tout d'abord, nous construisons l'indice de vulnérabilité macroéconomique-sociale-financière pour 10 pays d'Amérique du Sud entre 1978 et 2014 afin de mesurer le niveau d'incertitude. Cet indice est composé de sous-indicateurs macroéconomiques, de développement social, de liquidité, de solvabilité et de vulnérabilité du marché, par le biais d'un modèle d'équation structurelle des moindres carrés partiels (PLS-SEM). Nous identifions les niveaux de risque élevés (ingérable, intolérable et instable) et faibles (gérable, modéré, stable et fort) à l'aide d'un thermomètre régional d'incertitude en appliquant une méthode d'alerte précoce utilisant trois méthodes d'apprentissage automatique (i) l'analyse discriminante linéaire (LDA), (ii) les k-voisins les plus proches (KNN) et (iii) les machines à vecteurs de support (SVM). Nos résultats sont robustes et cohérents, car l'indice de vulnérabilité macroéconomique-sociale-financière capture les périodes de crises pour chaque pays étudié au cours de cette période. Ensuite, nous évaluons le risque macro-financier de contagion systémique en Amérique du Sud en examinant si le commerce et la mondialisation financière sont des moteurs de la transmission macro-financière systémique et nous détectons s'il existe un risque de contagion macro-financière à travers l'interconnexion de la synchronisation des cycles économiques, du commerce bilatéral et des accords commerciaux entre les 10 pays d'Amérique du Sud pendant la période 1978-2014, en utilisant des techniques économétriques spatiales. Nos résultats sont robustes et montrent que la globalisation financière et la globalisation du commerce sont toutes deux des canaux de transmission macro-financière. En conséquence, une augmentation de la libéralisation financière conduit également à une augmentation du risque macro-financier. Par contre, quand la libération commerciale augmente, le risque macro-financier diminue. De plus, nous vérifions que la propagation de la contagion provient des trois liens analysés à travers une dépendance entre les

pays à risque macro-financier de la région Sud-américaine. Enfin, nous monitorons le risque systémique dans la région à travers des scénarios de stress, qui identifient l'incertitude monétaire et de liquidité face à des chocs macroéconomiques, en considérant le régime d'inflation haute et basse et le régime d'expansion et de contraction économique, en utilisant le modèle non linéaire du modèle vectoriel autorégressif à seuil (TVAR) dans les pays d'Amérique du Sud pour la période 2006T1-2020T2. Notre principale conclusion est que lorsque le choc de liquidité augmente en Bolivie, au Chili, au Paraguay et en Uruguay, le régime de faible inflation augmente également. Dans le cas du choc de liquidité sur le régime de croissance économique, ils montrent des dynamiques différentes dans chaque pays. En revanche, lorsque la masse monétaire augmente, le taux d'intérêt diminue à court terme pour l'Argentine et l'Uruguay, mais à long terme pour le Brésil. Dans le cas de l'Équateur et du Paraguay, à court et moyen terme, lorsqu'il y a une expansion monétaire, le taux d'intérêt augmente, mais il n'y a pas d'impact sur l'inflation. En outre, le Chili et la Bolivie ont un choc monétaire positif sur le taux d'intérêt à court et à long terme.

Mots des clés: risque macroéconomique-financier, modèle d'alerte préventive, globalisation commerciale et financière, modèles d'économétrie spatiale, modèles de stress non linéaires et seuils de risque.

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1. CHAPTER I: INTRODUCTION

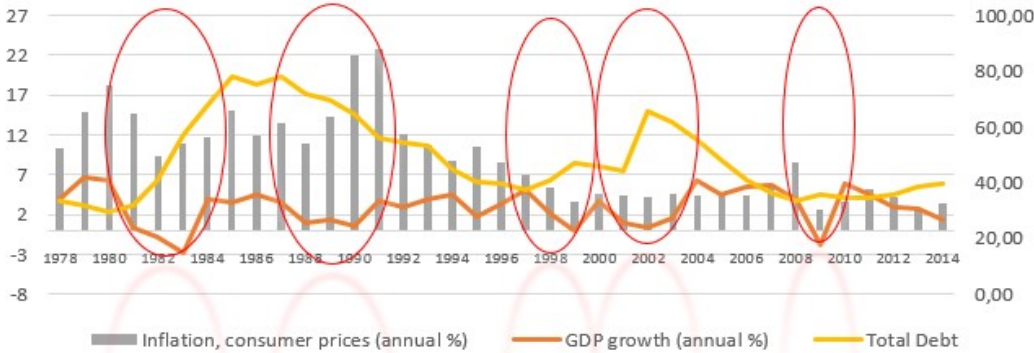
This chapter presents a brief analysis of the periods of macro-financial vulnerability experienced by South American countries. In addition, the purpose and main research findings of each chapter are described in general terms.

1.1. THE CONTEXT OF SOUTH AMERICAN COUNTRIES: PERIODS OF MACRO-FINANCIAL VULNERABILITY

The greatest crisis that swept over South American countries in the 80s known as the “lost decade” was caused by the default on their debt repayments was combined with the sharp depreciation in their currencies. The increase in the interest rates and hyperinflation swelled fiscal deficits that produced a cycle of insufficient expansion as a consequence of this negative growth rates in per capita income. Therefore, there was a higher social structure inequality, reaching the poverty rate of 40 percent in 1980¹.

This macro-financial vulnerability has been coupled with the evolution of globalization in several South American countries, reflected by the expansion of cross- border trade and capital flows since the mid-1980s following the great external debt. In the figure 1, we can identify the periods of crisis, which are manifested at the beginning and end of the 80s and 90s and in the period from 2000 to 2003, 2008 to 2009 and from 2013 , due to high levels of inflation, economic growth decline and in some of these periods, due to increases in total debt.

Figure 1. Crises periods of Latin American Countries



Source: World Development Indicators Database by the World Bank

¹Data available at Database of Economic Commission for Latin America (ECLAC), 2013.

At the beginning of the 1990s, Latin American economies entered into a period of slow, unbalanced growth. However, Argentina and Uruguay suffered an economic downturn in 1994-1995 and the majority of Latin American countries, a severe economic recession by the deterioration of the banking financial systems that produced a decrease of the liquidity, increased market volatility, the loss of purchasing power and unemployment rising despite the increase in informal employment in 1999-2000.

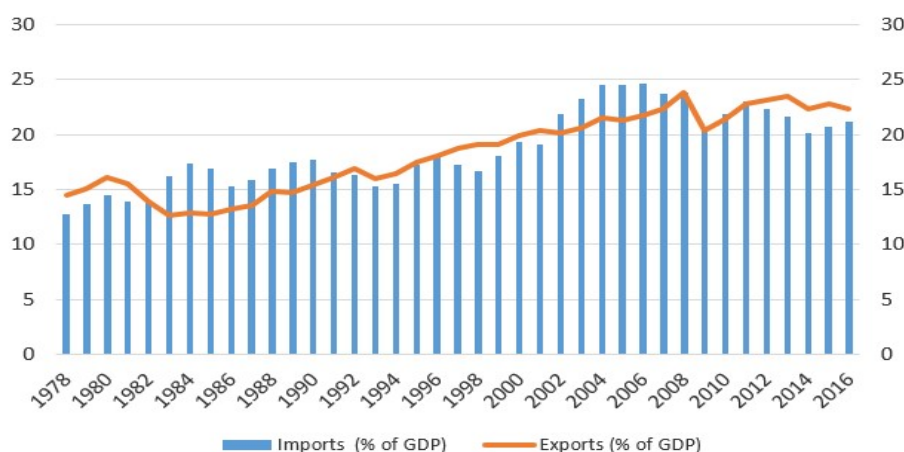
Latin American governments, which in early 2008 paid for their liabilities a rate of between two and three points above the rate paid by the US Treasury, saw that rate treble in the next few months. Among the seven major economies (Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela- LAC7), Venezuela and Argentina performed worst. In Argentina, the risk premium rose to the levels seen just before the default in 2001-2002, and in Venezuela this variable remained systematically above 1000 basis points. In the rest of LAC7 countries, in contrast, while the impact of the crisis was clearly noticeable, once the period of major turmoil in developed countries had passed, sovereign risk began to fall in accordance with the movement of emerging markets.

The decline in external financial conditions also had an impact in the form of rationing: many countries in the region were denied access to international markets. On the one hand, loans (syndicated and others) from global banks fell by 40 percent in the last quarter of 2008 with respect to the same period in 2007 (Jara et al, 2009). The impact of this was particularly severe on Central American countries (which are classified along with Mexico in the LAN sub-region), where the financial systems are bank-intensive and foreign penetration is high (Swiston, 2010).

The South American region, in general, economically affected again in the period 1998-2002 from a stagnation of fiscal revenues again originated by the deficit in balance-of-payments and a high inflation even though this dropped to two digits. The economic condition improved in the “commodity boom period” between 2003-2008, where oil-producing countries increased their trade balances, thus helping to alleviate fiscal deficits by raising the current account balance, increasing social spending and maintaining stable inflation levels.

The international crisis of 2008-2009 was transmitted to some South American economies through reduced export volumes and less abundant but more expensive external financing, given the deterioration in the terms of trade and the reduction of remittances from abroad. Indeed, for South American countries three-quarters of the decline in export revenues is explained by the downturn in export prices. The figure 2 shows a decrease in exports and imports in 2008-2009 period, whereas the exports present an increase in 2010 but from 2013 the exports decreased again, and imports increased (Fernández-Arias and Montiel, 2010).

Figure 2. Exports and Imports

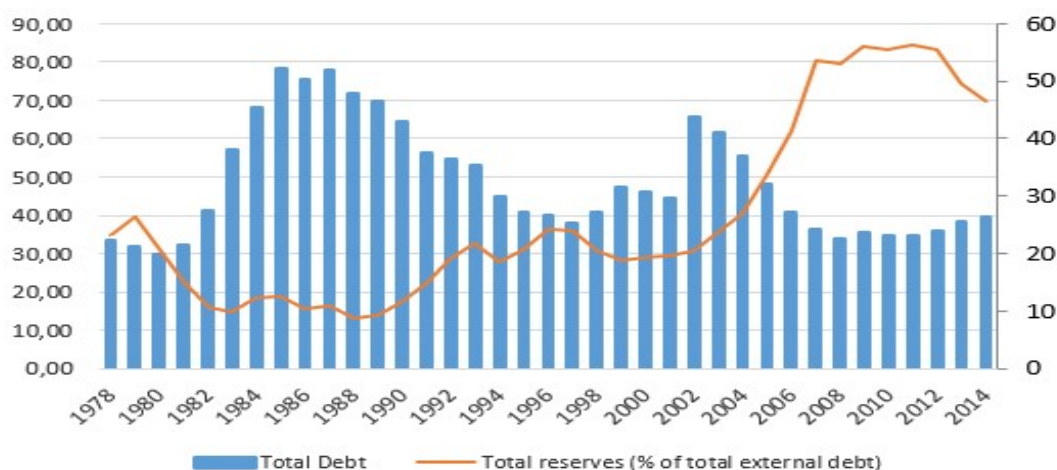


Source: World Development Indicators Database by the World Bank

Most South American countries adopted some measures to mitigate the 2008 financial crisis, such as strengthening the Central Banks and maintaining low and stable inflation rates. In addition, most of these countries introduce adjustments on the fiscal and monetary sectors to attenuate the trade deficit, depreciating their currencies discreetly, providing an automatic stabilizing effect in response to external financial shocks. Despite this, countries such as Brazil and Chile had volatile exchange rates and were the South American countries with the greatest exchange rate instability in 2008 (Fernández-Arias and Montiel (2010) and Ocampo (2009)). Although Ecuador’s currency is the dollar, and it was also affected by the fall in oil prices in 2008, it recovered in 2009, since it used oil funds to inject banking liquidity, which generated banking stability.

In this context, the majority of South American economies implemented institutional reforms in the financial sector, injecting liquidity using their accumulated international reserves, in order to mitigate the lack of external capital injection, for example Colombia and Peru. In addition, the reestablishment of these economies was helped by the fact that their banking system did not have the toxic assets that the banks in the United States had. However, there was some decline in credit (Ocampo (2009) and Blanco (2010)). In view of the fact that the sources of external financing were restricted by the crisis, the total debt decreased and the reserves also, as shown in the figure 3. The reserves increased in 2008 for 2009 but since 2012 they show a decreasing behavior and the external debt grew again from 2011.

Figure 3. Total Debt service and Total Reserves



Source: World Development Indicators Database by the World Bank

Following the increase in the price of oil and other minerals, South America presented a subdued growth until 2011, but unfortunately, the region’s economic situation started to taper by volatile exchange rates rising, with the imminent rise of US interest rates, the increase of the external debt as well as a deterioration in the balance of payments. This caused the contraction of economic expansion that was reflected by growth in the region of just 2.6 percent in 2013. Since 2014, most Latin American countries show signs of an economic contraction as a consequence of the slowdown in the Chinese economy in the face of falling demand primary goods that produced on par the drop of the export’s goods. So then, the region’s growth rate was barely 1.4 percent in 2014². These situations are detailed in Ocampo (2009), Ocampo (2014), Ocampo et al. 2018b and IMF (2016).

South American economies presented an economic decline of 2.4 percent in 2016 and a recovery of 0.8 percent in 2017, originated by the increase of exports as a consequence of a greater trade opening, given the new trade agreements between Europe and countries such as Colombia and Peru, and by the price increases of certain commodities. This allowed to reduce the current account deficits. By 2018, South America experienced 1.2 percent economic growth. However, certain countries such as Argentina, Venezuela and Ecuador presented fiscal deficits, minimum liquidity levels and high debts in 2019. In addition, the instability of oil prices and the increase in the cost of external financing has limited the inflow of capital, adding to this the decrease in fiscal spending and the growth of inflation, which has generated an economic slowdown ((ECLAC, 2017), (ECLAC, 2018a), (ECLAC, 2019)). This was aggravated by the sanitary crisis that occurred in 2020 in most of the countries of the region.

²Data available at Statistical Yearbook for Latin America and the Caribbean (ECLAC), 2013.

1.2. PURPOSE AND MAIN RESEARCH FINDINGS

In view of the vulnerability of South American economies in the face of global economic and financial crises, the uncertainty of commodity prices, the increase in risk premiums, government indebtedness due to the shortage of capital, and the contraction of economic growth in recent years, it is encouraging to South America to develop macro-prudential policies and the implementation of early risk assessments have been developed in order to measure, identify, monitor and anticipate systemic risk. To determine these policies, it is necessary to identify the level of macroeconomic and financial risk, evaluating the possibility of transmission or contagion in the region in the face of economic globalization. In a similar vein, the development of a stress system would allow the evaluation of uncertainty of liquidity in the face of possible high and low levels of inflation considering macroeconomic shocks, in order to monitor liquid assets versus short-term debt. These are sensitive aspects in South American economies and necessary to determine guidelines that will allow macroeconomic and financial risk in the region to decrease.

For this reason, this research will first analyse the concepts of vulnerability, crisis, and contagion and will evaluate the periods of macroeconomic and financial vulnerability in South America. In addition, this study proposes the construction of a macroeconomic and financial vulnerability index in order to identify the level of risk. This research then propose to evaluate the contagion of macroeconomic and financial risk considering trade and financial openness. Finally, a stress system will be proposed to evaluate the liquidity and monetary risk in the face of a high or low inflation and GDP growth regime versus the macroeconomic shocks, given that South American economies in recent years have shown minimal levels of liquidity. The following is a summary of each of the chapters:

Chapter 2 focuses on how vulnerability or risks and the types of crisis have been defined in the existing literature. In addition, this review discusses how vulnerability is measured and what warning systems or methods have been used to monitor macroeconomic and financial risks in recent years. This chapter also assesses the mechanisms of contagion, considering the impact of trade and financial openness on developing countries. At the end of this chapter, we mention the importance of monitoring uncertainty through stress techniques as a guide to develop prudential policies focused on reducing risk exposure.

Chapter 3 presents a study that aims to develop an uncertainty thermometer to identify and measure the macro-social-financial risk of 10 South American countries from 1978 to 2014. This thermometer is based on the early warning models to facilitate systemic risk monitoring. Contrary to other studies, we build a macroeconomic-social-financial vulnerability index (MSF) composed of macroeconomic, social development, liquidity, solvency and market vulnerability sub-indicators through the Partial Least Squares structural equation model. The uncertainty prediction is estimated using three classification algorithm methods: (i) linear discriminant analysis (LDA), (ii) k-nearest neighbors (KNN) and (iii) support vector machines (SVMs). These machines linear methods analyse the behavior of the sub-indicators. Finally, we calculate the cut-offs and standard deviation of both high and low uncertainty, considering the predictive classification obtained, to determine the high sub-zones (unmanageable, intolerable and unsta-

ble) and low sub-zones (manageable, moderate, stable and strong). The results are robust and consistent, because the MSF index is composed of a parsimonious set of variables, allowing to captures periods of high uncertainty presented in the region. The MSF vulnerability index captures periods of a high level of uncertainty (unstable, intolerable and unmanageable) presented in this region as a slowdown in the economic cycle produced in the following crisis periods of 1982–1985, 1989 and 1999–2002. We find that Chile, Uruguay and Paraguay show a low level of uncertainty (stable and moderate) in MSF vulnerability index in most periods studied. On the contrary, Brazil, Argentina and Venezuela presented high signals of vulnerability in 2014.

Chapter 4 examines if trade and financial globalization are drivers of macro-financial systemic transmission. It detects if there is a macro-financial contagion risk through the interconnection of a country's economic cycle synchronization, bilateral trade and trade agreement linkages among 10 South American countries for the 1978-2014 period, using spatial econometric techniques. Our results are robust and find that both financial and trade globalization are channels of macro-financial transmission. Given that, an increase of financial openness lead to the macro-financial risk also increases. On the other hand, when trade openness increases, the macro-financial risk decreases. Furthermore, we verify that the propagation of contagion derives from the three linkages analyzed by a cross-country dependency with macro-financial risk in the South American region. The results also report that the macro-financial risk increases when the terms of trade volatility also rises, this could be due to the fact that most of these countries export commodities which have volatile prices. Moreover, we confirm that an increase of other external factors such as the volatility of the official exchange rate and financial instability (dummy crisis) leads to an increase in the macro-financial risk. We also find that the level of the MSF vulnerability increases due to the decline of the GDP growth and financial development. Finally, the first Durbin robustness model proposed shows that if the high-technology exports and oil price decrease, the MSF vulnerability index increases. Furthermore, the impacts of these factors allow to determine that there is a macro-financial systemic contagion risk when the financial openness is affected by a downturn in the economic cycle and a change or dissolution of a trade agreement.

Chapter 5 focuses on the fact that South American countries have experienced liquidity crisis at the end of the 80s and 90s as a cause of bank instability and the increase of external debt. In recent years, there are countries such as Argentina and Ecuador that have declined their liquidity levels significantly. Our study proposes to build a system which identifies the liquidity and monetary effects on macroeconomic shocks considering stress scenarios through a high or low inflation and GDP growth regimes, using the threshold vector autoregressive model (TVAR), a non-linear model in South American countries for the period between 2006Q1 and 2020Q2. Our main finding when evaluating the impact of liquidity, in most countries, when inflation increases, liquid assets to cover short-term debt also increase under the high and low inflation regime. In the case of Bolivia, Chile, Paraguay and Uruguay, the inflationary effect was greater when the shock occurred in the low inflation regime. While in countries with a high inflation regime, the nominal exchange rate tends to devaluate, as in the case of Venezuela and Argentina. On the other hand, as the money supply increases, interest rates tend to decrease,

leading to higher aggregate demand and higher inflation in the case of Argentina and Uruguay in the short term and Brazil in the long term. In addition, Chile and Bolivia present a monetary shock with respect to the volatility of the interest rate both in the short term and in the long term.

2. Chapter II: Review of the literature on Vulnerability, Risk, Crisis and Contagion

2.1. INTRODUCTION

Once established the main subject of this dissertation, we found appropriate to start an approach by reviewing the existing literature on certain concepts. Hence, this chapter reviews studies conducted on vulnerability, crisis and mechanisms of contagion and stress test. The review first focuses on how vulnerability of risks and the types of crisis have been defined in the existing literature. In addition, this review discusses how vulnerability is measured and what warning systems or methods have been used to monitor macroeconomic and financial risks in recent years. This chapter also assesses the mechanisms of contagion, considering the impact of trade and financial openness on developing countries. Finally, we describe the main stress methods used to monitor macro-financial risks in South American countries.

2.2. DEFINING VULNERABILITY

The meaning of the word “vulnerability” etymologically associates the word with exposure to damage or harm and with precariousness. The term “economic vulnerability”, when applied to a country, is generally used to refer to that country’s susceptibility to being harmed by external economic forces as a result of exposure to such forces. Most authors dealing with this subject consider economic vulnerability to be a disadvantage.

This concept of economic vulnerability was initially championed by Briguglio (1995) in the context of Small Island Developing States (SIDS) when he recognized that SIDS faced special disadvantages associated with small size, insularity, remoteness and proneness to natural disasters. Those factors render the economies of those states very vulnerable to forces outside their control. In the first published version of the vulnerability index, Briguglio (1995) argued that high vulnerability scores are undesirable because they measure the extent to which a country is exposed to harmful external shocks. Guillaumont (2009) called “vulnerability the risk of being harmed, wounded (negatively affected) by unforeseen events, in general and in economics as well.” Vulnerability may thus be viewed as an economy’s proneness to downside risks. Later this concept was developed into a conceptual framework applicable to all countries. The literature on economic vulnerability is still developing, with new definitions, determinants and measurement procedures being suggested.

Briguglio and Galea (2003) called “economic vulnerability” inherent, permanent or quasi-permanent features of a country which render that country exposed a very high degree economic forces outside its control and includes (a) economic openness, (b) export concentration (c) peripherality and (d) dependence on strategic imports as the principal variables that constitutes economic vulnerability.

Different sources of vulnerability can also be identified in the literature, Guillaumont (2009) follows that approach including two vulnerability sources: environmental and external shocks. These sources bring to the fore the important role of geography and size in determining the magnitude of vulnerability as indicated Briguglio and Galea (2003). The external shocks are trade and exchange-rate-related, include slumps in external demand, world commodity price instability (and correlated instability of terms of trade), as well as international fluctuations in interest rates. Besides identifying financial and external market imbalances as potential sources of vulnerability, Hermansen and Röhn (2015) point out that public sector imbalances and contagion as sources of vulnerability.

Importantly, by 2003 the conceptual framework went beyond an examination of the underlying structural determinants of macroeconomic vulnerability and began to focus on a complementary and important concept: that of resilience. Briguglio and Galea (2003) referred “economic resilience” as a country’s ability to economically cope with or withstand its inherent vulnerability, being a result of some deliberate policy. In 2009, Briguglio called the term “economic resilience associated with actions undertaken by policymakers and private economic agents which enable a country to withstand or recover from the negative effects of shocks. As is the case of vulnerability, resilience may also be inherent or nurtured.

The inherent aspect of resilience may be considered as the obverse of vulnerability, in the sense that countries that inherently lack economic resilience are economically vulnerable. Nurtured resilience, on the other hand, is that which can be developed and managed, often as a result of deliberate policy. The relevance of resilience is that it is often nurtured, in that public institutions may be capable of designing policies to mitigate the effects of vulnerability. There are many factors that could strengthen economic resilience of vulnerable countries, including: improving the competitiveness of the economy, building a sound macroeconomic environment, improving governance, diversifying the economy to reduce excessive reliance on a narrow range of exports, strengthening the transport and communications infrastructure.

Briguglio and Galea (2003) also identified four possible scenarios into which countries may be placed according to their vulnerability and resilience characteristics, he called the “worst case” scenario is which characterized by high exposure to shocks and lack of resilience policies. In particular, the results of the resilience index presented by Briguglio et al. (2009) showed that the economic well-being of nations is more dependent on man-made policies than on inherent vulnerabilities.

Cardona (2007) defines economic resilience as the capacity to face and recover from the impact of hazardous events and Baritto (2008) proposes a different macroeconomic vulnerability index that considers external economic and financial shocks, including the impact of natural disasters. Cardona and Baritto views of resilience are informed by the context of natural disasters. Since natural disasters impact economic growth by destroying the physical stock of capital, an economy’s resilience is determined by a country’s ability to mobilise its ‘own available funds’ to replenish its capital stock.

The most developed version of this framework was presented in 2009 by Briguglio distinguish-

ing between inherent economic vulnerability and nurtured economic resilience. It is possible to create a methodological framework for assessing the risk of being affected by external shocks

$$RISK = VULNERABILITY - RESILIENCE$$

The concept of risk has two elements, the first one is associated with the inherent conditions of the country that is exposed to external shocks and the second, associated with conditions developed to absorb, cope with or bounce back from adverse shocks. The risk of being adversely affected by external shocks is therefore the combination of the two elements. The negative sign in front of the resilience element indicates that the risk is reduced as resilience builds up.

Cordina (2004), Baritto (2009), Briguglio et al. (2009), and Essers (2015) define macroeconomic vulnerability as the uncertainty generated by various structural conditions which could cause a decrease of economic growth in the face of market or financial shocks. These financial perturbations are originated by market imperfections and financial instability. In addition, the interaction between these shocks also generates impacts on social development vulnerability, which could affect, directly or indirectly, the population's quality of life.

Economic vulnerability is defined as the exposure of an economy to exogenous shocks, arising out of economic openness, while economic resilience is defined as the policy-induced ability of an economy to withstand or recover from the effects of such shocks.

2.3. DEFINING CRISIS AND TYPE OF CRISIS

The existing studies identify crisis as the effect of vulnerability. This implies that when a country is susceptible to negative shocks, then it is highly possible that it will go through a crisis. The study of economic crises in general is relatively undeveloped, mostly because crises are difficult to model formally (Krugman et al., 1991). In spite of this informality, the most influential writers on crisis, notably Minsky and Kindleberger, are insistent that there is a general model of crisis-that it is a mistake to try to subdivide the crisis problem into particular subcases. Kindleberger in particular is sharply critical of the idea that "the genus 'crises' should be divided into species labeled commercial, industrial, monetary, banking, fiscal, financial and so on" (Kindleberger, 1978). On the contrary, other authors (Bordo and Meissner, 2016; Laeven and Valencia, 2012; Reinhart and Rogoff, 2011) have proposed concrete definitions of many types of financial crises. For Bussière and Fratzscher (2006), there are various types of financial crises: currency crises, banking crises, sovereign debt crises, private sector debt crises, equity market crises.

The literature has suggested that all types of crisis can be very costly and that there are possible causal relationships between various types of crises (Kaminsky, 1999; Reinhart and Rogoff, 2011).

2.3.1. BANKING CRISIS DEFINITION

The traditional view of a banking crisis was a banking panic or liquidity crisis. According to Bordo (2002), to qualify a banking crisis we must observe either bank runs, widespread bank failures and the suspension of convertibility of deposits into currency such that the latter circulates at a premium relative to deposits (a banking panic), or significant banking sector problems resulting in the erosion of most or all of banking system collateral that are resolved by a fiscally underwritten bank restructuring (erosion of most of all of aggregate banking system capital). Other authors are more specific to set conditions to qualify as an event of crisis, such as Reinhart and Rogoff (2009), who define that a banking crisis occurs when there are one of two types of events: 1) bank runs that lead to the closure, merging, or takeover by the public sector of one or more financial institutions; or 2) if there are no runs, the closure, merging, takeover, or large-scale government assistance of and important financial institution (or groups of institutions) that marks the start of a string of similar outcomes for other financial institutions. Laeven and Valencia (2012) define a banking crisis as an event that meets two conditions: 1) significant signs of financial distress in the banking system (as indicated by significant bank runs, losses in the banking system, and /or bank liquidations), 2) significant banking policy intervention measures in response to significant losses in the banking system. They consider policy interventions in the banking sector to be significant if at least three out of the following six measures have been used: 1) extensive liquidity support (5 percent of deposits and liabilities to nonresidents), 2) bank restructuring gross costs (at least 3 percent of GDP), 3) significant bank nationalizations, 4) significant guarantees put in place, 5) significant asset purchases (at least 5 percent of GDP) and 6) deposit freezes and/or bank holidays.

2.3.2. INFLATION CRISIS DEFINITION

Reinhart and Rogoff (2004), which classified exchange rate arrangements for the post–World War II period, used a 12-month inflation threshold of 40 percent or higher to define a “freely falling” episode. Accordingly, Reinhart and Rogoff (2011) define an inflation crisis using a threshold of 20 percent per annum. Hyperinflations are defined as episodes where the annual inflation rate exceeds 500 percent.

2.3.3. CURRENCY CRISIS DEFINITIONS

Currency crises were a frequent occurrence of emerging countries throughout the nineteenth and twentieth centuries. How to identify currency crises has been debated since the mid 1990s and one of the most accepted definitions about currency crisis in the literature is that of Frankel and Rose (1996) who define a currency crash as a depreciation of the nominal exchange rate of at least 25 per cent, that is also at least a 10 per cent increase in the rate of nominal depreciation. Other authors built their definitions of crisis following this approach, such as Laeven and Fabian (2018) who define a currency crisis as a nominal depreciation of the currency vis-à-vis the U.S. dollar of at least 30 percent that is also at least 10 percentage points higher than the rate of depreciation in the year before; and, Reinhart and Rogoff (2011) who describe an episode of

crisis for the entire period in which annual depreciations exceed the threshold of 15 percent per annum.

Bordo (2002) defines as a forced change in parity abandonment of a pegged exchange rate, or an international rescue. Or, an exchange market pressure above a critical threshold (calculated as a weighted average of exchange rate change, short-term interest rate change, and reserve change relative to the same for the center country. A crisis is said to occur when this index exceeds a critical threshold. We score an episode as a currency crisis when it shows up according to either or both of these indicators.

Currency crises often coincide or occur in quick succession with other types of crises, for instance together with banking crises in what has been dubbed the “twin crises” (Kaminsky, 1999).

2.3.4. DEBT CRISIS DEFINITIONS

A debt crisis arises when fiscal authorities are unable to raise sufficient tax revenue in the present and the future to service and amortize debt. Reinhart and Rogoff (2011) argue external debt crises involve outright default on payment of debt obligations incurred under foreign legal jurisdiction, including nonpayment, repudiation, or the restructuring of debt into terms less favorable to the lender than in the original contract. They also talk about domestic debt crisis. Indeed, as Reinhart and Rogoff (2009) show, it typically occurs against much worse economic conditions than the average external default. Domestic debt crises do not usually involve external creditors and references to arrears or suspension of payments on sovereign domestic debt are often relegated to the footnotes of data tables. That’s why those episodes go usually unnoticed.

Laeven and Valencia (2012) include the concept of sovereign debt default and restructuring as well as episodes of the former by relying on information from Beim and Calomiris (2001), World Bank (2002), Sturzenegger and Zettelmeyer (2006), IMF Staff reports, and reports from rating agencies. They identify 66 episodes of sovereign debt crisis and debt restructuring during the period 1970–2011, of which 3 episodes occurred during 2008–2011.

According to Bordo and Meissner (2016), a debt crisis can become a banking crisis when it impinges on its system and a currency crisis when it threatens central bank reserves. Banking crises can feed into debt crises when the fiscal authorizes bailout insolvent banks, which then increases sovereign debt until it becomes unsustainable. Debt crises can spill into banking crises when these hold sovereign debt.

2.3.5. SYSTEMIC CRISES DEFINITION

According to Reinhart and Rogoff (2008, 2009, 2018), a systemic crisis involves some combination of bank runs, losses in the financial system, and bank liquidations usually with attendant policy intervention to support the financial system. This situation impacts countries at a macro and micro level due to the fragility and vulnerability of economies.

Several authors evaluate systemic financial crises at a macro and micro level. For example,

Frankel and Saravelos (2010) assess the incidence of crisis by using drops in GDP and industrial production. The final sources of crisis cover fiscal deficit (Babecký et al., 2014) and currency depreciation, stock market performance and reserve losses (Saravelos, 2010).

2.4. VULNERABILITY MEASURES AND MONITORING METHODS

Since the end of the 1990s, there has been an extensive literature relying on the indicators of vulnerability that apply the Early Warning Models (EWM) as systemic risk measures. The EWM are signal models that identify uncertainties and predict the probability of a situation of vulnerability or crises, according to the behavior of the whole economy and the health of the financial systems through non-parametric or parametric methods, using bivariate models and panel vector autoregressive models. The objective of EWS is not to predict the exact timing of a crisis, but to predict whether it occurs within a specific time horizon (Bussière and Fratzscher, 2006).

The measurement of vulnerability as indicated in the existing literature entails quantitatively assessing the magnitude of vulnerability. In this sense, some studies have proposed a set of indicators to assess the degree to which economically vulnerable countries, as a group or individually, are moving ahead or otherwise, in coping with or withstanding economic vulnerability. One of the indicators considered is the Economic Vulnerability Index (EVI) proposed by Briguglio and Galea (2003). The principal variables used by the authors in the construction of their Economic (EVI) are (a) economic openness, (b) export concentration (c) peripherality and (d) dependence on strategic imports as the principal variables that constitutes economic vulnerability. Economic openness captures the degree to which a state is susceptible to economic conditions in the rest of the world, export concentration captures the extent to which a country lacks export diversification, a condition exacerbating the degree of economic openness, peripherality is associated with insularity and remoteness, leading to high transport costs and marginalization from main commercial centers, and dependence on strategic imports is intended to measure the extent to which a country's viability depends on imports.

Other authors propose indicators for economic resilience. Cardona (2007) proposes a straightforward and practical approach based on the computation of a Disaster Deficit Index (DDI) for which economic resilience is estimated in terms of the feasible internal or external funds a government can have access once the damage has been produced, taking into consideration that the government is responsible for recovering or is the owner of the affected infrastructure. The components of the DDI are: insurance and re-insurance payments, available reserves in disaster contingent funds, aid funds and donations, possible new taxes that could be created in case of a major disaster event, budget reallocation margin, referred to the government's discretionary expenditure margin, feasible external credit that could be obtained from multilateral bodies or from external capital markets, feasible internal credit from commercial banks and, in some cases, from the Central Bank. According to this author, these aspects constitute a direct measure of economic resilience in terms of a country's capacity to recover the losses on the damaged physical inventory. Another approach is presented in Baritto (2008), which is contained in a pro-

posed prototype named the Economic Vulnerability Resilience Monitor (Econ-VR). The key factors proposed by this author include the following: diversification of exported products, diversification of market destinations, non-poor population, net food import ratio, manufacturing and services value-added proportion. ratio of international reserves to imports by combining the above mentioned factors. Baritto tests the hypothesis that economies that are highly impacted by natural disasters are also highly susceptible to economic and financial shocks.

Cardona's and Baritto's views of resilience are informed by the context of natural disasters. Since natural disasters impact economic growth by destroying the physical stock of capital, an economy's resilience is determined by a country's ability to mobilise its 'own available funds' to replenish its capital stock.

Briguglio et al. (2009) propose The Economic Resilience Index by analysing macroeconomic stability, microeconomic market efficiency, good governance and social development. An important fact to be highlighted is the strong correlation observed between this Resilience Index and per capita GDP. They use economic openness, export concentration and dependence of strategic imports as key measures of vulnerability. The authors also consider the issue of resilience, measured by the ability of an economy to recover from the effects of shocks and how it withstands shock.

Babecký et al. (2014) propose an index of real cost that combines a continuous index of real cost with a binary index of crisis occurrence. The continuous index reflects the output and employment loss along with the fiscal deficit, while the binary index captures the occurrence of various (banking, debt, and currency) crises in EU and OECD countries over 1970–2010 using panel vector autoregression to select optimal horizons.

The results of the existing studies show that the choice of variable plays an important role in measuring vulnerability and this affects the weight placed on each variable's contribution. Indeed, as Hawkins and Klau (2000) point out, there is a general lack of conclusion about the variables that matter and the weight each one should get. Methodologically, quantitative approaches have been widely used to measure economic vulnerability. Dominant approaches used in the literature include linear regression, limited dependent variable probit/logit modelling (Caramazza et al. 2000; Corsetti et al. 1998; Demirguc-Kunt and Detragiache, 1998; Deutsche Bundesbank, 1999; Eichengreen and Rose, 1998) and non-parametric approaches. A key element in these studies is the construction of the crisis dummy variable. It is also important to distinguish between fragility in general and crises in particular, and between localized crises and systemic crises.

The non-parametric approach entails evaluating the power and usefulness of different variables in signalling a crisis, with a threshold chosen for each variable in order to distinguish between the risk of false signals and that of missing crisis.

Some authors have proposed indices to measure macroeconomic vulnerability, exchange or banking crisis using the standard deviation or weighted average of certain variables that give a vulnerability signal, as in Kaminsky et al. (1998), Herrera and Garcia (1999), Goldstein et al. (2000), Burkart and Coudert (2002), Edison (2003), and Bussière and Fratzscher (2006).

In recent years, a great majority of authors have identified economic and financial vulnerabilities through discrete models (logit or probit) in order to determine the probability of uncertainty in the face of a crisis, as in Frankel and Saravelos (2012), Lo Duca (2013), Babecký et al. (2014), Ferrari and Pirovano (2015). However, failing to distinguish between tranquil periods and crisis/post-crisis episodes may introduce an important bias in the estimation results and thus worsen our ability to anticipate financial crises. That's why Bussière and Fratzscher (2006) move from a binomial logit model to a multinomial logit model to improve the predictive power of the EWM substantially. Most recently, machine learning techniques such as binary recursive trees have been used to determine leading indicator crisis thresholds, while neural networks and genetic algorithms have contributed to the selection of the most appropriate indicators, as in Sarlin (2013) and Holopainen and Sarlin (2016).

In the same context, Guachamín et al. (2020) measure a macro-social-financial event risk through the construction of a Macroeconomic-Social-Financial (MSF) vulnerability index composed of macroeconomic, solvency, liquidity, market and social development vulnerability subindicators. The contribution of the study is to provide an early warning signal model, which measures and identifies the level of macro-social-financial vulnerability according to the behaviors of South American economies.

2.5. CONTAGION

It is well accepted that economic and financial vulnerability have increased in recent years. Even though it is a hard task to explain the origins of such vulnerability, stock market bubbles, currency fluctuations, banking crisis, credit contraction, high levels of external debt, fiscal deficit and external shocks are some of the factors usually believed to influence the well-being of economies (Claessens et al., 2014; Cardoso et al., 2014a).

The existing literature has measured vulnerability and crisis from the perspective of contagion, defined by economic shocks spilling over from one country to another (Essers, 2013). The focus on contagion has informed the focus on exposure and resilience. As seen in recent years, crises can result in deep and long-lasting recessions and, in some cases, can trigger sharp current account reversals. However, not all crises are preceded by such events. Some crises can be contagious and rapidly spread to other countries with no apparent vulnerabilities (Claessens et al., 2014), others are inherently different from periods of tranquility (Rigobon, 1999). The empirical literature on contagion has attempted to identify the channels of transmission of shocks using alternative methodologies.

Valdés and Hernández (2010) use a simple definition of contagion to identify the channels that explain cross-country co-movement during crisis periods. For them, contagion occurs when a country A gets into trouble because country B gets into trouble. Masson (1998) states that contagion occurs when the crisis in the first country affects investors' expectations in the second, upsetting the equilibrium of the latter economy and causing a crash and; Eichgreen et al. (1997) focus on contagion as a case where knowing that there is a crisis elsewhere if a single country falling victim to a crisis is not a particularly good predictor of crisis elsewhere because con-

tagion is highly non-linear. Furthermore, when the number of crisis in a given cluster is high, financial sector links, via common bank lenders are a powerful channel of fundamentals-based contagion (Kaminsky and Reinhart, 2000).

Economic literature suggests that contagion can occur because of trade links, both direct trade among countries and competition in third markets, similar initial conditions, whereby, countries co-move insofar as they have similar macroeconomic characteristics, and financial linkages (Valdés and Hernández, 2001).

Trade links can explain increases in the probability of a crisis at home. However, contagion is highly non-linear because of the possibility of competitive devaluations. Because the government may attempt to safeguard the country's competitiveness by devaluating its currency and the macroeconomic similarities channel explains contagion because countries with bad fundamentals are either bound to have a crisis or may enter a multiple equilibria zone (Valdés and Hernández, 2001).

Newbery and Stiglitz (1984) and Rodrik (1997) mention that an increase of trade market and capital flows can also increase macroeconomic volatility and make the domestic economy more vulnerable to greater external risk. In the same context, Kose et al. (2003) find that trade openness has a positive and significant relationship on volatility of the GDP growth only in the OLS model for both industrialized and developed countries from 1960 to 1999. This would suggest that if economies are more open, they are also more vulnerable to external shocks, but this study did not find a significant relationship between financial openness and macroeconomic volatility.

Valdés and Hernández (2001) argue that financial linkages explain contagion in several ways, each associated with one particular theory, namely i) direct financial linkages, ii) financial market institutional practices, iii) foreign investors liquidity problems and iv) information asymmetries and herd behavior. Direct financial linkages refer to direct cross-country investments, which tie corporate and financial sector returns. Financial market practices refer to institutional arrangements whereby countries are treated as complementary assets and fund managers use simple rules of thumb. As for liquidity problems, Valdés (1997) constructs a model in which emerging market financial claims are illiquid and bad news from a particular country measured by a lower probability of repayment, generates a higher probability of a run against other emerging markets, and therefore, a lower probability of repayment in these other countries. Information asymmetric information and herd behaviour include a series of theories based on capital market distortions that produce co-movement across countries. Herding behaviour by indiscriminating investors is often blamed for producing common outcomes in countries with very heterogeneous fundamentals .

Calvo (1999) examines the case in which the capital market is populated by informed and uninformed investors. The uninformed try to extract information from informed investors' trades. In particular, after a crisis fund managers need to sell securities to finance possible redemptions by investors. However, in the process of selling "good" countries, the market penalizes them because of the well-known lemon problems.

The heterogeneity in the bilateral transmissions of shocks are driven by the asymmetries be-

tween international trade and financial linkages. These linkages vary according to the behavior of cross-border capital and financial flows (financial globalization) and reduction of barriers on the free exchange of goods and service to promote trade openness Lane and Milesi-Ferretti (2003). However, it is difficult to distinguish between the trade and financial links, because most countries that are linked in trade are also linked in finance (Kaminsky and Reinhart, 2000).

Some authors claim that the cross- country contagion of crises is a characteristic of open economies since foreign capital movements are potentially volatile or risky and the majority of foreign competition weakens local intermediaries. Furthermore, Stiglitz (2000), Schmukler and Zoido-Lobaton (2006) and Obstfeld (2008) the likelihood that these transmission channels will be extended to other countries may also be increased by trade balance deficits, external and internal indebtedness, exchange rate, remittances and financial speculation. Other authors consider that that banking crises are more likely to occur in a liberalized financial system if there is no transparency, diversification and solid banking supervision regulation. Kaminsky and Reinhart (2000) and Calvo and Reinhart (1996) agree the fact that contagion is more regional than global.

Valdés and Hernández (2001) sets contagion occurs through different channels simultaneously and some channels might be more important during particular events. Recently, there are spatial studies that have specifically investigated the impact between the financial openness and financial crisis. For example, Triki and Maktouf (2012) use a spatial model to assess the relationship between financial liberalization and financial stability in 40 emerging countries between 1989 and 2010. They demonstrated that financial integration increases when there is a period of crisis. In the same context, Jing et al. (2018), analyze the propagation of financial crisis via bilateral trade, bilateral banks' foreign claims and distance channels in order to determine the interdependence effects in the pre-crisis and crisis periods for 40 countries from 2003 to 2010.

2.6. STRESS TESTING

Stress tests are a useful tool to identify and evaluate the impact of potential sources of risk, which, could affect economic and financial stability at the micro and macro levels when a negative shock is generated. Stress tests can be targeted to identify different vulnerabilities or risk situations, including liquidity, market and solvency risk. Stress tests identify adverse shocks that may originate from internal or external situations reflecting through individual or regional effects Tobias et al. (2020).

In this sense, tress testing is a mechanism to identify vulnerabilities in risk management and provide relevant information for decision making by supervisory institutions and central banks. In several cases, the stress tests are using as a guide to develop prudential policies focused on reducing risk exposure. Most of central banks in South America have implemented stress tests based on top-down solvency stress tests. Although the central banks of Brazil, Chile, Colombia and Uruguay have also developed top-down liquidity stress tests. Furthermore, in the majority of countries, the market risk has been assessed through the interest rate uncertainty in the face of macroeconomic shocks, the yield curves and the balance sheet exposures of the financial

system, while for currency risk evaluates the shocks caused by exchange rate variations of the main currencies exposed by funds or investments that banks maintain, using linear econometric models such as VAR, VEC or DSGE Ulloa (2020) and Tobias et al. (2020).

In the case of liquidity risk, Caggiano et al. (2017) developed a stress test focused on assessing the uncertainty of US liquidity in normal and speculative periods, using nonlinear models called Threshold Vector Autoregressive (TVAR), in order to identify "liquidity traps" and determine thresholds according to the Dow Jones index as a regime variable to distinguish between speculative and normal risk episodes during the Great Depression (1921-1940) and the recent Great Recession (1991-2010). This study identified that an increase in M2 generated an effect on liquidity in the period of the Great Depression, while in the period 1991-2010 it was shown that a liquidity shock generates a weak response of the long-term nominal interest rate.

In the case of Latin America, Ulloa (2020) not only evaluated the stress test methodologies formulated by Argentina, Brazil, Chile, Colombia, Mexico, Peru and Uruguay, but also proposed a common stress test exercise considering a stressed macroeconomic scenario composed of an instantaneous, unexpected and permanent shock, causing macroeconomic variables to present a volatile behavior for two years. This study identified that the final impact on banking indicators has important differences between some countries due to factors such as the treatment of variables used in each country (measurement, frequency, etc.), the difference between Basel standards varies between each country, and that the common scenario does not affect all countries at the same level. However, the main effect is the decrease of the banking indicators ROA and the solvency level of financial institutions and of each country.

2.7. CONCLUSION

This chapter provides a review of the literature on vulnerability, crisis, types of crises, contagion, warning methods to identify periods of macroeconomic and financial vulnerability. An important conclusion is that vulnerability can originate in the real or financial sector generated by internal or external shocks associated with structural conditions, developing as an uncertainty or risk, which can be of a short-term or long-term duration and according to its level of intensity or impact, this uncertainty can generate a crisis.

In view of the fact that macro-financial uncertainty can increase or decrease and can originate both in the economic or financial sector at the micro and macro levels, this chapter evaluated the techniques for measuring vulnerability or early warning methods, with the aim of determining the methods that make it possible to identify uncertainty by measuring its level of intensity or impact.

On the other hand, the probability of the transmission of macro-financial uncertainties may originate through commercial or financial channels, which explain the co-movement between countries during periods of crisis or by transmission of impact between one crisis and another, considering this it is important to evaluate the process of contagion of macro-financial vulnerability according to the economic situation and commercial co-movement between the countries

of the region.

Finally, it was possible to conclude the importance of building a monitoring or stress system to identify impact thresholds or limits that serve as a guide for decision making, so at the end of this chapter we mention the application of some methods developed by the Central Banks of some South American countries to assess solvency, liquidity and exchange rate risk, in order to manage risk and design mitigation guidelines that stimulate the development of macro-prudential policies.

3. CHAPTER III: AN UNCERTAINTY THERMOMETER TO MEASURE THE MACROECONOMIC FINANCIAL RISK IN SOUTH AMERICA COUNTRIES

3.1. INTRODUCTION

After the review of certain concepts this chapter elaborates a vulnerability index by taking into consideration risk factors such as macroeconomic, solvency, liquidity and social development, among others in order to identify and measure risk levels through an Early warning model (EWS).

Most South American countries experienced economic downturns in the late 1980s due to rising inflation external and public debt, depreciation of their currencies and liquidity problems in the financial sector. This period was known as the “lost decade”, which was marked by the decreases in reserves due to the lack of bank liquidity, leading to a banking crisis at the end of the 1990s in countries such as Argentina and Ecuador (ECLAC, 1996; Bértola and Ocampo, 2012; Laeven and Valencia, 2012; Ocampo, 2014).

The economic condition for South America improved in the “commodity boom period” between 2004-2007, where oil-producing countries increased their trade balances, thus helping to alleviate fiscal deficits by raising the current account balance, increasing social spending and maintaining stable inflation levels. Following the increase in the price of oil and other minerals, South American countries presented a subdued growth until 2011, but unfortunately, the region’s economic situation started to taper due to volatile exchange rates, causing the rise of US interest rates and the increase of external debt. Since 2014, some South American countries have shown signs of economic contraction as a result of falling commodity prices and Chinese demand for primary goods. These situations are detailed in Ocampo (2009), Ocampo (2014), Ocampo et al. (2018a) and IMF (2016).

In view of such uncertainty periods, it seems necessary to identify the periods that present adverse economic conditions which trigger lower growth rates, and to measure the intensity of the vulnerability that could affect economic and financial regional integration. Hence, the main question that arises in this paper is *what can be done to measure and identify the levels of macroeconomic-social-financial vulnerabilities of 10 South American countries?*

In order to answer this question, it is important to consider what the macroeconomic and financial vulnerabilities in a country implies. Cordina (2004), Baritto (2009), Briguglio et al. (2009), Guillaumont (2010) and Essers (2015) define macroeconomic vulnerability as the uncertainty generated by various structural conditions which could cause a decrease of economic growth in the face of market or financial shocks. These financial perturbations are originated by market imperfections and financial instability. In addition, the interaction between these shocks also generates impacts on social development vulnerability, which could affect, directly or indirectly, the population’s quality of life.

Based on these vulnerabilities, we propose to construct an index that identifies macroeconomic, financial and social vulnerabilities, considering that the liquidity, solvency and market problems are part of financial vulnerability. Our empirical study covers Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay and Venezuela from 1978 to 2014. The contribution of this study is to provide an early warning signal model (EWS), which measures and identifies the level of macro-social-financial vulnerability according to the behaviors of South American economies. This model will facilitate risk monitoring and help to anticipate possible crises through the identification of risk thresholds.

Some authors have proposed indices to measure macroeconomic vulnerability, exchange or banking crisis using the standard deviation or weighted average of certain variables that give a vulnerability signal, as in Kaminsky et al. (1998), Herrera and Garcia (1999), Goldstein et al. (2000), Burkart and Coudert (2002), Edison (2003), and Bussière and Fratzscher (2006). In recent years, a great majority of authors have identified economic and financial vulnerabilities through discrete models (logit or probit) in order to determine the probability of uncertainty in the face of a crisis, as in Frankel and Saravelos (2012), Lo Duca (2013), Babecký et al. (2014), Ferrari and Pirovano (2015). Currently, machine learning techniques are also used to define uncertainty thresholds between false alarms and missing signals by calculating the noise to signal ratio, as in Sarlin (2013) and Holopainen and Sarlin (2016).

Contrary to these proposals, our study aims to measure a macro-social-financial event risk through the construction of a Macroeconomic-Social-Financial (MSF) vulnerability index composed of macroeconomic, solvency, liquidity, market and social development vulnerability sub-indicators. To find the variables that are part of these sub-indicators, we use the partial least squares structural equation model (PLS-SEM) of second order by linear equations to identify: i) if there is a causal relationship between the latent variables theoretically proposed (sub-indicators) and observable variables and ii) if the sub-indicators and the dummy crisis variables make up the MSF vulnerability index.

The contribution to the related early warning literature is that we measure the exposure of the risk by the construction of an *uncertainty regional thermometer*, for which we first determine a high and low level of uncertainty by the *k*-means cluster method. Second, we standardize the MSF index by calculating the *z*-score. In addition, the robustness of the classification is checked and the uncertainty prediction is estimated using three classification algorithm methods: 1) linear discriminant analysis (LDA), 2) *k*-nearest neighbors (KNN) and 3) support vector machines (SVM), which analyze the behavior of the sub-indicators. Finally, we calculate the cut-offs and standard deviation of both high and low uncertainty, considering the predictive classification obtained, to determine the high sub-zones (unmanageable, intolerable and unstable) and low sub-zones (manageable, moderate, stable and strong).

In addition, our study includes variables that measure social development vulnerability, which allows us to analyze economic behavior according to the development of South American societies. Indeed, other than the common indicators suggested by previous research, we use some development indicators. We do so because South American countries have multiple development disparities associated with poverty, education quality and public health. Therefore, it

seems necessary to establish an indicator that measures the impact of these vulnerabilities.

Our results are consistent since the MSF index is composed of a parsimonious set of variables. The MSF vulnerability index captures periods of a high level of uncertainty (unstable, intolerable and unmanageable) presented as a slowdown in the economic cycle produced in the following crisis periods of 1982-1985, 1989 and 1999-2002. We find that Chile, Uruguay, and Paraguay show a low level of uncertainty (stable and moderate) on the MSF vulnerability index in most periods studied. On the contrary, Brazil, Argentina, and Venezuela present high signals of vulnerability in 2014.³

The remainder of this chapter is structured as follows. In section 3.2 we describe the empirical methods for constructing vulnerability indicators. Section 3.3 explains the methodology. Section 3.5 presents the results obtained and discusses the level of uncertainty calculated according to the behavior of each MSF country index. Finally, conclusions are presented in section 3.6.

3.2. EMPIRICAL REVIEW ON EARLY WARNING MODELS

Since the end of the 1990s, there has been an extensive literature relying on the indicators of vulnerability that apply the Early Warning Models (EWM) as systemic risk measures. The EWM are signal models that identify uncertainties and predict the probability of a situation of vulnerability or crises, according to the behavior of the whole economy and the health of the financial systems through non-parametric or parametric methods, using bivariate models and panel vector autoregressive models.

More in detail, Kaminsky et al. (1998) examine the evidence on currency crises and propose the use of an early warning system to determine noise-to-signal ratio through threshold values for certain emerging and advanced economies, using non-parametric methods. Subsequently, Kaminsky (1999) evaluates the levels of economic vulnerability of 20 countries in order to identify the currency and also the banking crisis by univariate methods, identifying the noise to signal-ratio of each indicator related with such crisis and measuring the probability of fragility through a quadratic and logit score. This study confirms the crises periods in the late 1990s in Argentina, Bolivia, Colombia and Brazil.

Contrary to Kaminsky (1999), Herrera and Garcia (1999) created a specific signal–method for Latin American countries according to the behavior of their own macroeconomic vulnerability index (IMV), using data from 1980 to 1998. IMV index is an aggregate indicator composed of domestic credit growth, M2/International reserves, inflation and the real effective exchange rate. They use the ARIMA residual approach to determine thresholds according to the probability of not anticipating a crisis (Type I error) and the probability of sending a false signal (Type II error). This study predicted crises occurred in Colombia in September 1998, Brazil in January 1999 and Ecuador in February 1999.

Several authors identify macroeconomic vulnerability periods according to structural condi-

³These results are also supported by Herrera and Garcia (1999) and the crisis database of Reinhart (2010), Laeven and Valencia (2012), Ocampo (2014) and IMF (2016)

tions, which affect economic growth in the face of trade sector, financial sector and social development (Cordina, 2004; Baritto, 2009; Briguglio et al., 2009; Guillaumont, 2010; Essers, 2015). Other authors have developed the EWM for monitoring debt, currency and banking crises using bayesian models, as in Demirgüç-Kunt and Detragiache (1999), Hawkins and Klau (2000), Fuertes and Kalotychou (2012), Babecký et al. (2014) .

In this broader perspective, Frankel and Saravelos (2012) and Lo Duca (2013) contribute to the financial crisis literature by developing a framework for assessing systemic risk and for predicting events in periods of extreme financial instability through bivariate regressions. Meanwhile, Reinhart (2010), Laeven and Valencia (2012) and Bordo and Meissner (2016) built a crisis database, which identifies the currency, banking, inflation and sovereign debt crisis periods according to theoretical definitions.⁴

On the other hand, Ferrari and Pirovano (2015) use a parametric model, which is estimated using a pooled conditional moment approach to identify the country's structural characteristics and dependencies, analyzing pre-crisis, non-crisis and tranquil periods, in order to determine country-specific signalling zones through binary threshold methods, and to obtain greater flexibility through compensation between Type 1 and Type 2 errors. Conversely, Supriyadi (2015) creates an external vulnerability index (EVI) as EWM, aggregating indicators through the Organization for Economic Cooperation and Development (OECD) methodology and using signaling method in order to capture the level of pressure: normal, alert, cautious, and suspected to crisis through the threshold based on the smallest noise to signal ratio.

In recent years, the early warning literature has used multivariate statistical techniques to estimate simultaneous causality relationships between quantitative or qualitative indicators, which are part of a concept or theory through the methodology of structural equations (SEM). There are two techniques for calculating structural equations: Covariance Based SEM (CB-SEM) and Partial Least Squares SEM (PLS-SEM). Such is the case of Mohr and Wagner (2013) that construct the financial stability indicators of 55 countries from 2001 to 2005 by CB-SEM. These indicators were made by a structural equation model to test the relationship between banking and financial, macroeconomic and regulatory indicators. The results reveal that macroeconomic disturbances have a negative impact on banking sector stability, while regulatory governance shows a direct relation with financial stability. Also, economic freedom seems to have a negative effect on the stability of the banking sector.

The PLS-SEM methodology has been more used than CB-SEM thanks to its method for estimating complex cause or effect theoretical relationships with latent variables in economic, social, marketing and finance areas, not only by reflective measurements but also by formative measurements and its less restrictive assumptions being non-normal data. In the economic area Adusei and Gyapong (2017) use the PLS-SEM approach to analyze the impact of macroeconomic variables on exchange rate volatility in Ghana, such as: inflation, monetary policy rate, current account balance, money and quasi money supply per GDP, annual GDP growth rate and the total external debt to the US dollar exchange rate in Ghana in the period 1975–2014.

⁴See, <http://www.carmenreinhart.com/data/browse-by-topic/topics/7/> <https://sites.google.com/site/michaelbordo/home4> (Fiscal and Financial Crises database)

Regarding finance, Avkiran (2018) make an application of PLS-SEM in financial stress testing. They show how PLS-SEM can be used to explain the transmission of systemic risk from shadow banking to the regulated banking sector by a set of indicators to measure the systemic risk of banks in Japan. They find out that shadow banking explains in a representative percentage the systemic risk in regulated banks.

Finally, there has been an increasing amount of literature based on early warning models as a tool to help reducing vulnerability and economic losses by non-linear machine learning techniques. For instance, Holopainen and Sarlin (2016) propose models for crisis prediction comparing conventional statistical and machine learning methods to determine the impact of cyclical connected systemic risk using vulnerability indicators of the real and financial sector of European countries as early warning methods. This study concluded that machine learning approaches have a potential to define uncertainty thresholds.

Summing up, the majority of early warning models have used similar economic and financial indicators. We add to this literature by proposing the construction of a development vulnerability indicator composed of social variables, unlike the traditional indicators.

3.3. METHODOLOGY

In this section, we first describe the database and the indicators used for the empirical model proposed (subsection 3.3.1). We explain in detail the methodology applied to build sub-vulnerability indicators that compose the MSF index for each Latin American country and also, the methodology to construct the noise to signal ratio for the uncertainty thermometer (subsection 3.4).

3.3.1. DATA

Overall, we use annual data from 1978 to 2014 and cover the following countries: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay and Venezuela. Our Macro-Social-Financial vulnerability index is composed of five sub-indicators: macroeconomic, solvency, liquidity, market and social development vulnerability. We select the observable variables that have a theoretical relationship with the definition of macroeconomic, solvency, liquidity, market and social development vulnerability. The majority of these variables are common in the early warning literature, as in Kaminsky et al. (1998), Hawkins and Klau (2000), Abiad (2003), Frankel and Saravelos (2012), Angelini (2011), Lo Duca (2013) and Supriyadi (2015).

Table 3.1 shows the observable variables used for this study distributed in macroeconomic, solvency, liquidity, market and social development vulnerability sub-indicators (latent variables). The data used for this study are available at the World Development Indicators Database by the World Bank and additional data is available at the International Financial Statistics (IFS) by the International Monetary Fund (IMF), the Inter-American Development Bank (IADB) data base, and different Central Banks.⁵

⁵The data are available at <https://data.worldbank.org/indicator>, <https://www.imf.org/en/Data> and Central banks pages.

Table 3.1. List of observable variables distributed in each vulnerability sub-indicator

Code	Observable Variables	Latent Vulnerabilities Sub-indicators	Latent Final Index
XME1	Inflation, GDP deflator (annual %)	$Y_1 =$ Macroeconomic Vulnerability	
XME2	GDP growth (annual %)		
XME3	Growth of primary sector (% of GDP)		
XME4	Growth of secondary sector (% of GDP)		
XME5	Growth of tertiary sector (% of GDP)		
XME6	Growth of Exports of goods and services (annual %)		
XME7	Cash surplus/deficit (% of GDP)		
XME8	Foreign direct investment, net outflows (% of GDP)		
XME9	Foreign direct investment, net inflows (% of GDP)		
XME10	Fiscal Revenue, excluding grants (% of GDP)		
XS1	Total Debt (% GDP)	$Y_2 =$ Solvency Vulnerability	
XS2	External Debt (% GDP)		
XS3	Central government debt, total (% of GDP)		
XS4	Total debt service (% of exports of goods, services and primary income)		
XS5	Gross public debt (% of GDP)		
XL1	Broad money (% of GDP)	$Y_3 =$ Liquidity Vulnerability	
XL2	Total reserves (% of total external debt)		
XL3	Liquid liabilities (% of GDP)		
XL4	Broad money to total reserves ratio		
XL5	Central Bank Assets to GDP		
XM1	Real effective exchange rate index	$Y_4 =$ Market Vulnerability	
XM2	Price capital stock		
XM3	Domestic credit to private sector (% of GDP)		
XM4	Market capitalization of listed domestic companies (% of GDP)		
XD1	Mortality rate, under-5 (% 1,000 live births)	$Y_5 =$ Social Development	
XD2	Poverty Gap 1,90 (% of population)		
XD3	Government expenditure on education, total (% of GDP)		
XD4	High-technology exports (% of manufactured exports)		
XD5	Health expenditure, total (% of GDP)		
XC1	Inflation crisis dummy	$Y_6 =$ Dummy Crisis Variables	
XC2	All crisis dummy		

 $\eta =$ Macroeconomic - Social - Financial Vulnerability Index (MSF)

Source: World Bank, IMF, IADB and Central Banks

We also consider two dummy variables, the first variable describes if there is an inflation crisis according to the data base of Reinhart (2010) and the second details if there is an exchange, banking and sovereign debt crisis according to the information provided by Laeven and Valencia (2012) and Bordo and Meissner (2016). We named this variable "all crisis dummy".

The majority of observable variables were estimated by their natural logarithm.⁶ The definitions of all the observable variables are detailed in Appendix A.1 table A.1.1 and the descriptive statistics of these variables in Appendix A.2 table A.2.2.⁷

3.4. EMPIRICAL METHODOLOGY

In this subsection, we first explain the method for building the the MSF vulnerability index using the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach and a method to build an uncertainty thermometer (sub-subsection 3.4.1 and 3.4.2).

3.4.1. METHOD FOR CONSTRUCTING THE MSF INDEX

The model of structural equations is an extension of several multivariate techniques such as multiple regression and factorial analysis (Kahn, 2006). However, the SEM has particular characteristics such as the ability to identify and estimate the existence of a causal relationship between unobservable or latent variables (theoretical concepts) and observable variables (indicators or ratios).

We use the Partial least squares path modeling methodology for the SEM estimation, which estimate the cause-effect relationships with latent and observables variables. PLS-SEM is a composite model approach, which estimates construct measures that approximate the conceptual variables in a model (Wold (1985) and Hair et al. (2017)). In contrast with covariance based SEM estimation, PLS-SEM maximizes the variance of dependent latent variables and minimizes the amount of unexplained variance, in order to maximize the R^2 values by an interactive sequence of OLS regressions, this is detailed in Hair et al. (2017). PLS-SEM also estimates efficiently complex models considering a small sample size . In addition, the data do not require an univariate and multivariate normality assumption for this type of models.

In our particular case, we use this method to build five exogenous constructs – macroeconomic, solvency, liquidity, market and social development sub-indicators, which compose one endogenous construct- macro-social-financial risk index (MSF). These sub-indicators are measured by means of multiple indicators. In addition, the endogenous construct MSF has two measured indicator variables: inflation crisis dummy and all crisis dummy.

We propose the following theoretical model to determine the macro-financial indicator (η_t)

⁶Except the following variables: XME2, XME3, XME4, XME5, XME7. XME8, XME9, XME10, XL5, XM2, XM4 and XD2.

⁷The growth of primary sector (% of GDP), foreign direct investment, net outflows (% of GDP) show a very high kurtosis, given that these variables do not present a multivariate normality. Byrne (2010) and Hair *et al.* 2010 argued that data is considered to be multivariate normal if skewness is between ± 2 and kurtosis is between ± 3 . In some cases kurtosis could reach a maximum range of ± 7 .

composed of each latent variable(Y_{fi}):

$$\eta_t = Y_{f1} + Y_{f2} + Y_{f3} + Y_{f4} + Y_{f5} + Y_{f6} \quad (1)$$

Where t indicates the time period and Y_{fi} are the following latent variables: Y_{f1} (macroeconomic vulnerability indicator), Y_{f2} (solvency vulnerability indicator), Y_{f3} (market vulnerability indicator), Y_{f4} (liquidity vulnerability indicator), Y_{f5} (development vulnerability indicator) and Y_{f6} (crisis latent variables).

PLS-SEM is composed of two components known as the measurement model or outer model, and structural model, also called inner model. According to Edwards and Bagozzi (2000), and Diamantopoulos et al. (2008) and Hair et al. (2017)), the measurement models identify the relationships between latent variables and their observable variables, which depend on the type of the relationships. These ones could be *formative* or *reflective* models. PLS-SEM has no restrictions to construct reflective and formative measurement with single and multi-items.

In our model the observable variables X_{ji} proposed for each sub-indicator are: X_{mei} (macroeconomic indicators), X_{si} (solvency indicators), X_{mi} (market indicators), X_{Li} (liquidity indicators), X_{di} (social development indicators) and X_{ci} (crisis latent variables).

Esposito et al. (2010) mentioned that there is a formative relationship when the latent variable is formed by the behavior of its exogenous variables i.e., the observed variables cause or compose a latent construct. The formative measurement mathematically is expressed as multiple regression:

$$Y_{fi} = \sum_j^i w_{ji} X_{ji} \delta_{ji} \quad (2)$$

Where Y_{fi} is each latent variable (sub-indicators of each country including the measured indicators of the MSF), while W_{ji} is the coefficient of each X_{ji} , which are the observable variables proposed for each sub-indicator and the δ_{ji} represents the residual term. The predictor specification of this model is the following:

$$E(Y_{fi}|X_j \dots X_{ji}) = \sum_j^i w_{ji} X_{ji} \quad (3)$$

The procedure to assess the formative measure involves the following main steps: i) examine the presence of collinearity among indicators, and ii) evaluate the significance and relevance of each indicator.⁸

On the other hand, when indicators are consequence or effects of the latent variable they are said to be *reflective* indicators. In this case, the indicators "reflect" or are manifestations of the latent variable (Bollen (1989) and Hair et al. (2017)). The reflective measurement is a factorial

⁸According to Hair et al. (2017), a related measure of collinearity is the variance inflation factor (VIF), which should be lower than 5.

function expressed by the following simple regression model:

$$X_{ji} = Y_{fi}\beta_{ji} + \delta_{ji} \quad (4)$$

Where X_{ji} are the observable variables theoretically proposed. The β_{ji} represents the regression coefficients and δ_{ji} is the vector of residual or error scoring unexplained by the model. The Y_{fi} must be isolated to obtain each vulnerability sub-indicator. The predictor specification of the measurement model assumed that the error δ_{ji} is zero. It is given by the following equation:

$$E(X_{ji}|Y_{fi}) = Y_{fi}\beta_{ji} \quad (5)$$

The aim of the reflective measurement model assessment is to ensure its internal consistency reliability and validity. The specific measures include the composite reliability (as a means to assess the internal consistency reliability), convergent validity, and discriminant validity.⁹

In the structural model, also called inner model, the latent variables are related with each other. Latent variables are divided into two classes, exogenous and endogenous. Exogenous latent variables do not have any predecessor in the structural model, all others are endogenous.

$$\eta_t = \sum Y_{Fi}\epsilon_{ji} + e_i \quad (6)$$

Where η_j denotes the endogenous latent variable; in our case, it is the Macro-social-financial vulnerability index (MSF), Y_{Fi} represents the exogenous latent variables, ϵ_{ji} are the regression coefficients, and e_i is the error term. Finally, the MSF index is composed of the results obtained by the sum of the structural model and the measurement model.

The path coefficients are estimated through a Partial Least Squares regression method. The PLS-SEM method determines the parameters of a set of equations in a path model, using a logarithm of optimization criteria, which defines a system weight w to be applied at each block q of observable variables X in order to estimate the latent variable. The general PLS-PM optimization criteria proposed by Tenenhaus and Tenenhaus (2011) is:

$$\max_{W_q} \left\{ \sum_{q \neq q'} C_{qq'} g(\text{cov}(X_q w_q, X_{q'} w_{q'})) \right\} \quad (7)$$

Where $C_{qq'} = 1$ if X_q and $X_{q'}$ are connected and $C_{qq'} = 0$ otherwise, $g = \text{square}$ when the factorial scheme is chosen or $g = \text{absolute value}$ when centroid scheme is used. We use the centroid scheme to estimate the coefficients, in which the weights are equal in absolute value and their signs reflect the correlation between the observable variables and their latent variables. If the

⁹According to Hair et al. (2017) the Cronbach's alpha is a conservative measure of internal consistency reliability (0.60 to 0.70 is considered acceptable). A common measure to establish convergent validity on the construct level is the average variance extracted (AVE), which should be to close or greater than 0.50 for each latent variable obtained. And, in evaluating the discriminant validity, we make the following comparison, called the Fornell-Larcker criterion: square roots of the AVEs should be greater than the correlations of the constructs of latent variables.

measurement model is reflective; the s.t. of $|X_q w_q|^2 = n$. On the other hand, if the measurement model is formative; the s.t. of $|w_q|^2 = n$.

The main evaluation criteria for PLS-SEM results are the coefficients of determination (R^2 values) as well as the level and significance of the path coefficients similarly as in any multiple regression analysis.¹⁰ Goodness of fit index (GoF) assesses the overall prediction performance of the model in both the inner and the outer models.¹¹ According to Esposito et al. (2010) and Sanchez (2013), GoF is acceptable when its value is higher than 0.7.

In order to implement the PLS-SEM by path model, we use a second-order model called "Two-Step Approach", since our model has two distinct dimensions: i) construction of sub-vulnerability indicators proposed (latent variables) according to the causal or effect relationship with the observable variables and ii) construction of the MSF index considering the behavior of sub-indicators calculated and dummy crisis variables. For this implementation, we propose a hypothetical model expressed in 4 types of higher-order constructs : 1) first-order formative – second-order formative 2) first-order formative - second order reflective, 3) first order reflective – second-order formative and 4) first order reflective – second-order reflexive. We select the best high - order model according to the fit criterion mentioned above.¹²

Figure 3.1 and 3.2 show the 4 types of higher-order model proposed. The following graphs describe the relationships among observed and latent variables using a path diagram. In this path diagram, the $Y_{f1} - Y_{f6}$ latent variables are displayed in ellipses figures. The variables in rectangular boxes represent the observable variables: $X_{me1}, \dots, X_{d1}, \dots, X_{s1}, \dots, X_{m1}, \dots, X_{L1}, \dots, X_{c2}$. (X_{mei} = Indicators related theoretically to macroeconomic vulnerability, X_{di} = Indicators related theoretically to social development vulnerability, X_{si} = Indicators related theoretically to solvency vulnerability, X_{mi} = Indicators related theoretically to market vulnerability, X_{li} = Indicators related theoretically to liquidity vulnerability and X_{ci} = Indicators related theoretically to crisis). These are associated to each latent variable, already mentioned in 3.1 by connecting lines, representing the possible causal relations. The macroeconomic-social-financial vulnerability indicator (MSF) is η_t and it is represented in the last ellipse. On the other hand, when indicators are consequence or effects of the latent variable they are said to be reflective indicators. In this case, the indicators "reflect" or are manifestations of the latent variable (Bollen, 1989).

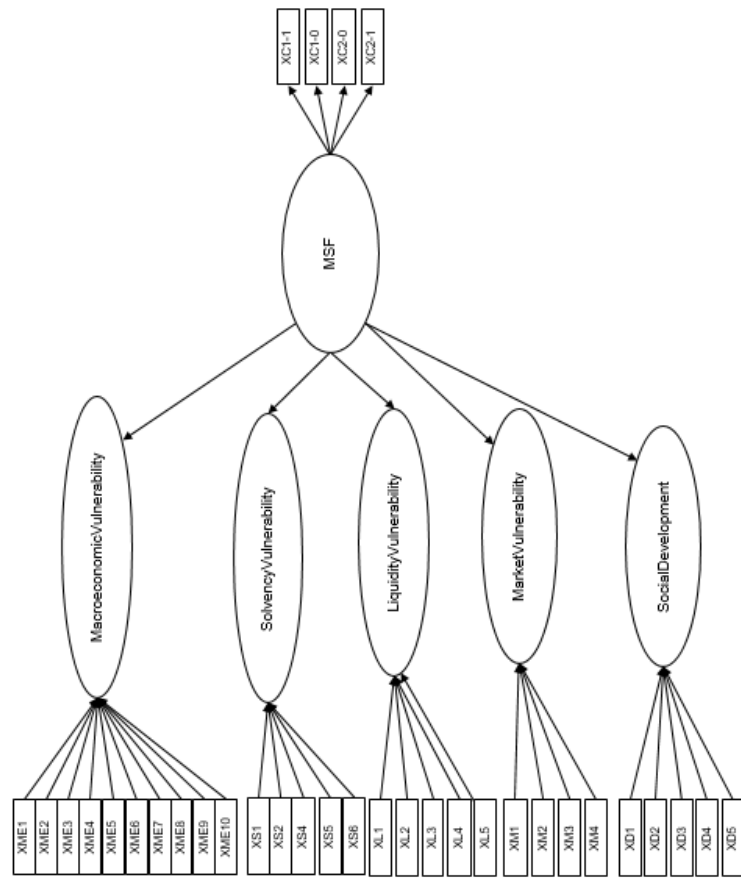
¹⁰The values of the R^2 can be classified in: i) Low= $R^2 < 0.20$, ii) Moderate= $0.20 < R^2 < 0.50$ and iii) High: $R^2 > 0.50$) (Sanchez, 2013).

¹¹The function of this index is similar to the Comparative fit index (CFI) used to evaluate the CB-SEM models.

¹²More details about higher-order models in Diamantopoulos et al. (2008) and Becker et al. (2012).

Figure 3.1. Path diagrams – Hypothetical models

(a) First order formative and second order formative



(b) First order formative and second order reflective

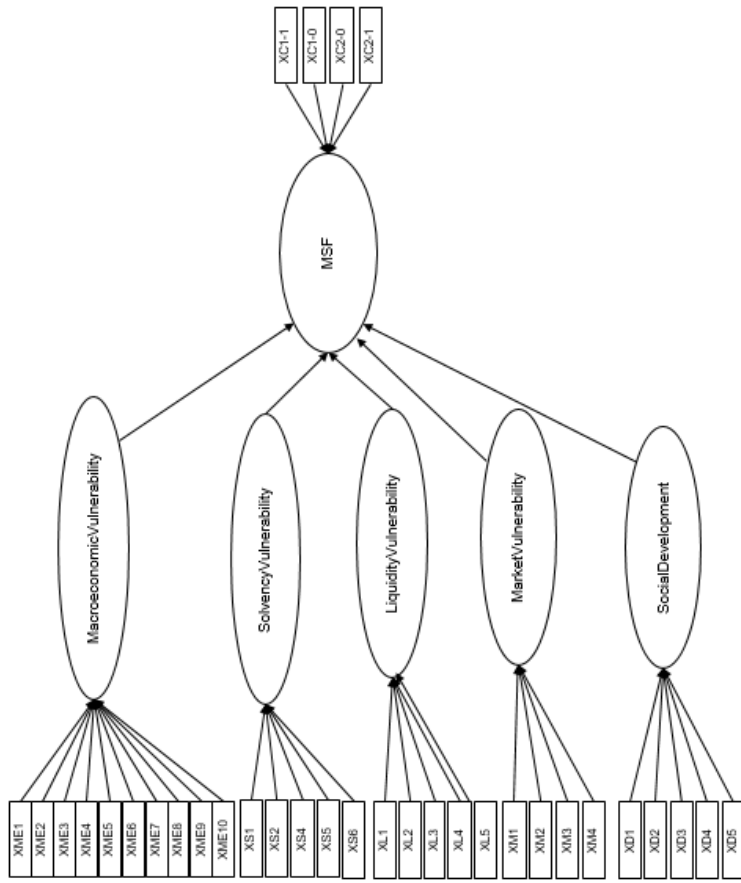
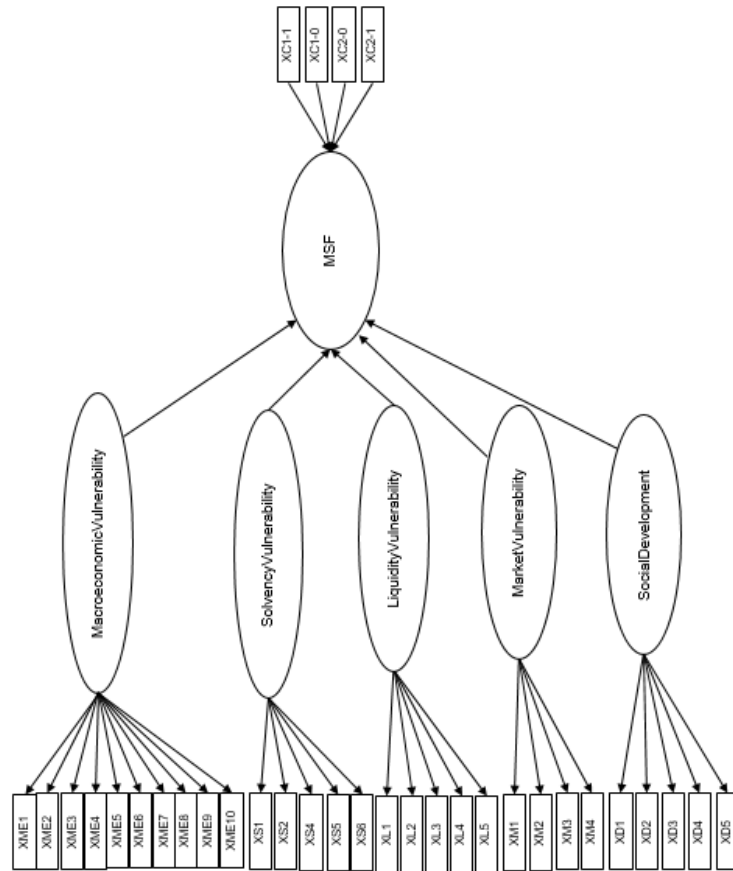
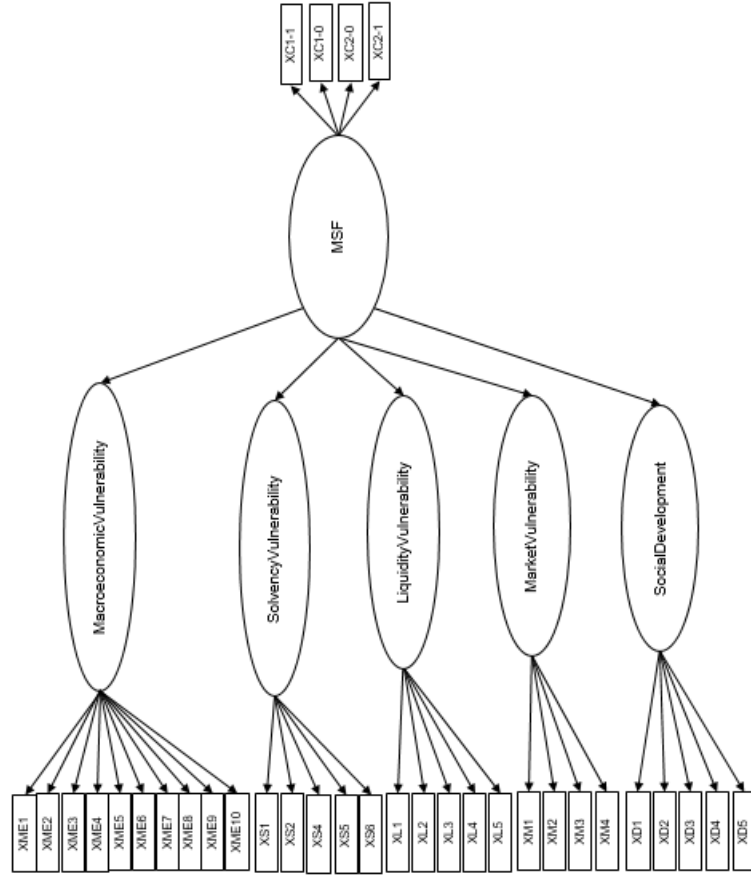


Figure 3.2. Path diagrams – Hypothetical models

(a) First order reflective and second order formative



(b) First order reflective and second order reflective



3.4.2. METHOD FOR THE CONSTRUCTION OF THE “UNCERTAINTY THERMOMETER”-EARLY WARNING MODEL

We constructed a cluster analysis by the K-means method to identify the risk level of each parameter of vulnerability for each South American country to determine the (high or low) level of uncertainty. The two groups -high uncertainty and low uncertainty- are formed according to the behavior of the MSF Index.

In addition, we calculated the Z-score from each MSF index of each country in order to obtain a normalized or standardized score. The Z-score is composed of the signal mean μ and the standard deviation of the noise σ , described in the following equation:

$$Z_{MSF} = \frac{Y_{fi} - \mu}{\sigma} \quad (8)$$

The aim of our early warning model is to determine the level of uncertainty of the standardized MSF index or Z-score, using three classification algorithm methods: 1) Linear Discriminant Analysis (LDA), 2) k -nearest neighbors (KNN), and 3) Super Vector Machines (SVM) on the sub-indicators obtained.¹³

KNN is a non-parametric method that estimates the probability of an observation for belonging to a class depending on what group the observations nearest to it are in. This method is the simplest data classification algorithm and the easiest to implement according to the following formula of standard euclidean distance:

$$\sqrt{\sum_{i=1}^k (x_i - y_i)^2} \quad (9)$$

Where an observation is classified by the majority vote of its neighbors and assigned to the most common class among its nearest neighbors K measured by the above distance function. If $K = 1$, then the observation is simply assigned to the class of its nearest neighbor.

LDA is a linear classification technique, similar to a Principal Component Analysis since both methods look for linear combinations of variables that best explain the data. This method is a generalization of Fisher’s linear discriminant that finds a linear combination of features that characterize or separate two or more classes of observations $P(X|y = k)$ which is modeled as a multivariate Gaussian distribution with density:

$$P(X|y = k) = \frac{1}{(2\pi)^{d/2} |\sum_k|^{1/2}} \exp\left(-\frac{1}{2}(X - \mu_k)^T \sum_k^{-1} (X - \mu_k)\right) \quad (10)$$

We assume that in population π the probability density function of x is multivariate normal with a mean vector μ and variance-covariance matrix \sum (same for all populations). d is the number of features.

¹³In line with Holopainen and Sarlin (2016), the machine-learning methods with highest usefulness are KNN and SVM.

Support Vector Machine (SVM) is a popular learning-based method for solving classification and regression problems, created by Cortes and Vapnik (1995). An SVM is a discriminative classifier formally defined by a separating hyper-plane. The basic idea is that given a set of points, a subset of a larger set (space), in which each of them belongs to one of two possible categories, an algorithm based on SVM constructs a model capable of predicting whether a new point, from which we do not know the category, belongs to one or another category. In our case we used the Weka implementation of John Platt's sequential minimal optimization (SMO) algorithm for training a support vector classifier.¹⁴ SVM has the following scoring function which computes a score for a new input and it uses the default polynomial Kernel function (K):

$$f(x) = \sum_{i=1}^m \alpha_i y^i K(x^i, x) + b \quad (11)$$

Where x^i , y^i represents the i training examples. x^i is an input vector which may be any dimension. y^i is a class label, which has one of only two values, either 0 or 1. While α_i is the coefficient associated with the i training example.¹⁵ The x is the input vector that we are trying to classify, b is just a scalar value and K is Kernel function.¹⁶

The centroids of Z-score of the MSF index are mean scores of high and low uncertainty classification, calculated from the three techniques of classification mentioned above. After having obtained the centroids, we proceeded to calculate the cut-off points which separate the two levels of uncertainty, which is composed of the average of the sum of c_1 (high uncertainty) and c_2 (low uncertainty) centroids:¹⁷

$$C = \frac{\bar{c}_1 + \bar{c}_2}{2} \quad (12)$$

Figure 3.3 shows the histogram of the alert threshold, which details the sub-zones of high uncertainty (unmanageable, intolerable and unstable) and low uncertainty (manageable, moderate, stable and strong) at the regional level. These sub-zones were calculated in this way: \bar{c}_1 (high level) or \bar{c}_2 (low level) $\pm \sigma$.

For training, validating and testing the predictive models, we created a training data-set and a test data-set. These were generated randomly considering 50% (185 instances) of the total data (370 instances) for the training data-set, used to generate the predictive models; and 50% (185 instances) for the test data-set, which is a held-out sample used to apply and evaluate the accuracy of the predictive models.¹⁸ Each instance is defined by the values of all the sub-indicators composed by the most significant observable variables described in table 3.1 for each pair (year, country) according to the data described in subsection 3.3.1. The class of each

¹⁴According to Hall et al. (2009)

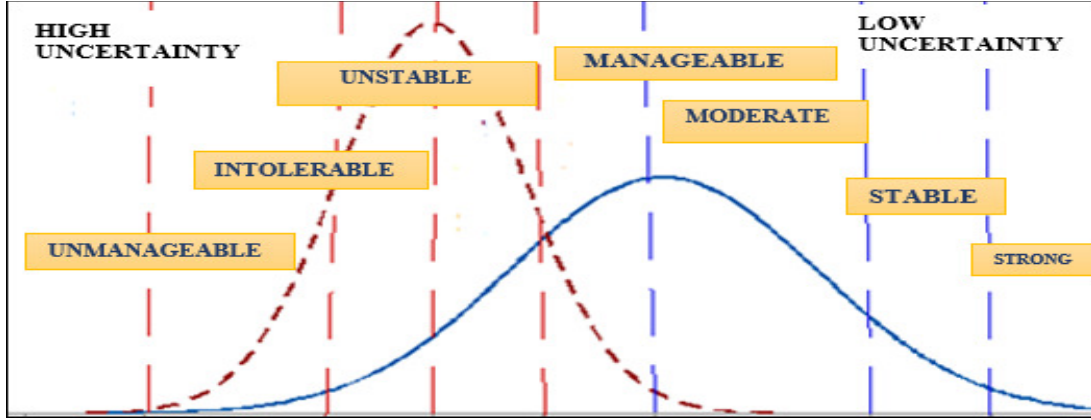
¹⁵The dual problem is to find $\alpha_1, \dots, \alpha_N$ (Lagrange multipliers), such that the above Lagrangian function is maximized and $\sum_{i=1}^N \alpha_i y_i = 0$; $\alpha_i \geq 0$ for all $1 \leq i \leq N$.

¹⁶We use the polynomial kernel function: $K(x, x') = (x \cdot x' + 1)^d$

¹⁷Both c_1 and c_2 are calculated according to the level of high or low uncertainty of all countries in all periods evaluated, in order to estimate the sub-levels of high and low risk at the regional level.

¹⁸It is important to recall that the training and test data-sets are selected randomly considering that the prediction is done regardless of time periods. The main objective is to predict according to the behavior of the risk sub-indicators of each country in each period. In this sense the country is considered as a feature as well.

Figure 3.3. Uncertainty threshold for the MSF vulnerability index



Source: Authors' elaboration

instance is given by the level of uncertainty (high or low), previously calculated according to the behavior of the MSF index, using the k-means cluster method.

With the aim of estimating a correct prediction of the macro-social-financial uncertainty and preventing over-fitting at hand, we performed a 10-fold cross validation during the training stage to generate our models. When using k-folds, the training data-set is divided in k equal subsets, which are known as folds (f_1, f_2, \dots, f_k) . This contributes to the validation of the predictive models generated, as each time a different fold is used for testing (test set), and the remaining folds are used for training (train set).¹⁹

Later, we applied the predictive models learned over the test data-set, and evaluated their performance on this remaining 50% of data, which was not used to train the model, and therefore emulated the application of the model over new unseen data.

We calculate the accuracy of each method at the train stage by averaging the derived accuracy of each cross validation iteration.²⁰ Then, we also calculate the accuracy of the models on the test data-set. It is important to recall that the centroids are calculated using as sample the predictions obtained for the instances of the test data-set, after having applied the model that was previously learned.

In order to assess the effectiveness of the three classification algorithm methods applied and determine the sub-zones of uncertainty (high or low), we calculate measures to evaluate the classification prediction. According to Ferrari and Pirovano (2015) the most common error prediction ratios used in the literature are the Type I error and the Type II error, which consider the following hypothesis:

$$\begin{cases} H_0 : & \text{a high-vulnerability occurs} \\ H_1 : & \text{a high-vulnerability does not occur} \end{cases}$$

¹⁹The cross validation test is used to compare the performance of different methods during the training stage, and to avoid over-fitting. In the case of the KNN and SVM, we applied a $k = 10$.

²⁰We keep the fold f_i as validation set and keep all the remaining $k - 1$ folds as the training set.

The error type I is the error of not rejecting a null hypothesis when the alternative hypothesis is the true state of nature. In other words, there is the possibility of classifying a highly vulnerable country into a lowly vulnerable country. On the contrary, error type II presents the rate of prediction error of classifying a lowly vulnerable country into a highly vulnerable country. Where the Type I error = $1 - TPR = \frac{C}{A+C}$ = false negative rate, which represents the fraction of missed crises and the Type II error = $\frac{B}{B+D}$ = false positive rate, which represents the fraction of false alarm. These situations are summarized in Table 3.2, which describes the following confusion matrix:

Table 3.2. Confusion Matrix of Z-score

		Predicted classification	
		Highly vulnerable	Lowly vulnerable
Actual Classification	Highly vulnerable	A The number of high-vulnerability periods also predicted by the model as high- vulnerability	B The number of high-vulnerability periods predicted by model as low-vulnerability
	Lowly vulnerable	C The number of low-vulnerability periods predicted by model as high-vulnerability	D The number of low-vulnerability periods also predicted by model as the low-vulnerability

Source: Authors' elaboration

According to Holopainen and Sarlin (2016), we can also use the following correctly predicted ratio given by:

- Precision ratio:
 Positive precision predictive value (PPV) = $\frac{A}{A+B}$
 Negative precision predictive value (NPV) = $\frac{D}{D+C}$
- Recall:
 Positive recall = $\frac{A}{A+C}$ = True positive rate
 Negative recall = $\frac{D}{D+B}$ = True negative rate
- Accuracy = $\frac{A+D}{A+D+B+C}$
- F–measure:²¹
 Positive F–measure = $\frac{2A}{2A+B+C}$
 Negative F–measure = $\frac{2D}{2D+B+C}$
- Noise to signal ratio (NSR) = $\frac{B/(B+D)}{A/(A+C)}$
- ROC curve (AUC) = the conditional probability of positives to the conditional probability of negatives.

²¹F–measure is the harmonic mean of precision and sensitivity.

3.5. EMPIRICAL RESULTS

This section illustrates the results obtained to build the sub-indicators and the MFS index. We also analyze the level of uncertainty obtained from each country in the studied period. The subsection shows: i) the baseline results of the PLS-SEM model and results of the implementation of the alert threshold (subsection 3.5.1), and ii) analysis of the level of uncertainty associated with the behavior of each vulnerability indicator (subsection 3.5.2).

3.5.1. BASELINE RESULTS OF THE PLS-SEM MODELS FOR THE CONSTRUCTION OF VULNERABILITY INDICATORS

We tested 4 hypothetical PLS-SEM models using XLStat software. Below, we present the most optimal solutions for the four proposed models. We chose the best structural and measurement models integrated by observable variables with significant relationships for each vulnerability sub-indicator (latent endogenous variables) and the significant relationship between sub-indicators and the MSF index.

Table 3.3 shows the main results of the goodness-of-fit measures for the 4 hypothetical models. The R^2 shows that the model that best fits the data is the "First Order-Formative and Second Order-Formative" model.²² See the path-diagram of the best model in Appendix A.3 in the figure A.3.1. We verified that this is the model that best fits the necessary conditions for constructing the sub-vulnerability indicators and the MSF index, since the GoF index in this model is higher than 0.7. In spite of the fact that the Gof index is high in all models, they do not comply with the adjustment requirements of the R^2 .²³

Table 3.3. Goodness-of-fit measure

Type of Model	Statistical adjustment measures	R^2	GoF
Model 1 (Best Model)	First Order - Formative Second Order - Formative	0.462	0.86
Model 2	First Order - Formative Second Order - Reflexive	0.235	0.87
Model 3	First Order - Reflexive Second Order - Formative	0.432	0.86
Model 4	First Order - Reflexive Second Order - Reflexive	0.219	0.86

Source: Authors' calculations

According to the results of the best model, the first construction order presents a formative relation between the sub-indicators and their observable variables; thus a variation in sub-indicators leads to a variation in all their measurable variables (Simonetto, 2014). In the case of the second

²²We present the R^2 average due to the fact that in each model proposed, we evaluated not only the structural model to obtain the MSF vulnerability index, but we also found that the liquidity sub-indicator shows a structural relationship with the macroeconomics and market sub-indicators, in addition to the fact that it has a formative relationship with certain observable variables theoretically proposed.

²³We also calculate the variance inflation factor (VIF) of each observable variable that is part of each sub-indicator in order to measure collinearity. All variables have a VIF below 5. See in Appendix A.2 in table A.2.2 .

order of construction, it also shows a formative relationship, i.e., a change in the sub-indicators obtained affect the MSF vulnerability index, the same happens if there are crises periods.

We made several estimates using the PLS-SEM method for each model proposed and discarded non-significant observable variables. Table 3.4 details only the coefficients of the significant observable variables obtained from the best estimates found for the four types of models proposed. These observable variables composite the sub-indicators. This table also reports the relationship between the sub-indicators and the MSF vulnerability index.

Table 3.4. Estimation Results of Standardized Regression

Observable Variable	Latent variable	Model 1	Model 2	Model 3	Model 4
Macroeconomic Vulnerability Indicator - First Order					
XME1 Inflation, GDP deflator (annual %)	→ Macroeconomic	0.958*** (0.043)	0.933** (0.054)	0.872*** (0.032)	0.853*** (0.035)
XME2 GDP growth (annual %)	→ Macroeconomic	-0.287*** (0.122)	-0.379** (0.103)	-0.456*** (0.110)	-0.497*** (0.081)
XME6 Growth of Exports of goods and services (annual %)	→ Macroeconomic	-0.496*** (0.108)	-0.529** (0.088)	-0.616*** (0.071)	-0.621*** (0.062)
Solvency Vulnerability - First Order					
XS1 Total Debt (% GDP)	→ Solvency	0.729*** (0.099)	0.780** (0.103)	0.761*** (0.042)	0.769*** (0.045)
XS2 External Debt (% GDP)	→ Solvency	0.481*** (0.013)	0.518** (0.113)	0.800*** (0.038)	0.80*** (0.039)
XS3 Central government debt, total (% GDP)	→ Solvency	0.892*** (0.062)	0.453** (0.034)	0.894*** (0.022)	0.887*** (0.021)
Liquidity Vulnerability Indicator - First Order					
XL1 Broad money (% GDP)	→ Liquidity	0.951*** (0.024)	0.933** (0.054)	0.916*** (0.011)	0.915*** (0.012)
XL2 Total reserves (% of total external debt)	→ Liquidity	0.534*** (0.073)	0.518** (0.113)	0.653*** (0.055)	0.657*** (0.045)
XL3 Liquid liabilities (% GDP)	→ Liquidity	0.933*** (0.033)	0.884** (0.074)	0.920*** (0.012)	0.918*** (0.012)
Market Vulnerability - First Order					
XM1 Real effective exchange rate index	→ Market	0.183** (0.096)	0.210** (0.020)	0.379** (0.127)	0.401** (0.121)
XM2 Capital Stock price	→ Market	0.235*** (0.107)	0.253** (0.107)	0.375*** (0.118)	0.391*** (0.130)
XM3 Domestic credit to private sector (% GDP)	→ Market	-0.989*** (0.013)	-0.986** (0.020)	-0.942*** (0.040)	-0.933*** (0.045)
Social Development Vulnerability - First Order					
XD1 Mortality rate, under-5 (% 1,000 live births)	→ Social Development	0.803*** (0.066)	0.778** (0.056)	0.842*** (0.032)	0.835*** (0.031)
XD2 Poverty Gap 1,9 (% population)	→ Social Development	0.352*** (0.117)	0.366** (0.103)	0.485*** (0.088)	0.488*** (0.082)
XD3 Government expenditure on education, total (% GDP)	→ Social Development	-0.812*** (0.059)	-0.829** (0.050)	-0.736*** (0.051)	-0.742*** (0.053)
Dummy Crisis Variables - MSF					
XC1 Inflation Crisis	→ MSF Index	0.997*** (0.006)	0.954** (0.018)	0.990*** (0.010)	0.943*** (0.015)
XC2 All Crisis	→ MSF Index	0.325*** (0.0321)	0.534** (0.085)	0.388*** (0.079)	0.564*** (0.072)
Macroeconomic-Social-Financial Vulnerability Index (MSF) - Second Order					
Macroeconomic Vulnerability	→ MSF Index	0.268*** (0.026)	0.570*** (0.043)	0.260*** (0.023)	-0.558** (0.040)
Solvency Vulnerability	→ MSF Index	0.146*** (0.020)	0.317*** (0.047)	0.133*** (0.019)	-0.293*** (0.034)
Social Development Vulnerability	→ MSF Index	0.210*** (0.019)	0.44*** (0.035)	0.207*** (0.017)	-0.432** (0.039)
Liquidity Vulnerability	→ MSF Index	-0.215*** (0.021)	-0.303*** (0.024)	-0.212*** (0.015)	0.294** (0.022)
Market Vulnerability	→ MSF Index	0.125*** (0.021)	0.240*** (0.054)	0.112*** (0.021)	-0.219** (0.053)

Note: 1) P-value are in parentheses, significant at 10% (*), at 5% (**), at 1% (***), 2)

In summary, the MSF vulnerability index is composed of three macroeconomic variables (GDP growth, inflation and export growth), three solvency variables (total debt, external debt and central government debt), three liquidity variables (broad money to GDP, total reserves to external debt and liquid liabilities to GDP), three market variables (price capital stock market, domestic credit to GDP and real effective exchange rate) and three social development variables (mortality rate, poverty gap and government expenditure on education to GDP).

The macroeconomic vulnerability sub-indicator is positively influenced by inflation (GDP deflator), i.e., if this variable increases in one point, the level of macroeconomic vulnerability rises in 0.9 points. On the other hand, we confirm that if GDP growth (annual %) and Growth of exports of goods and services (% of GDP) increase one point, this behavior leads to a decrease of the macroeconomic vulnerability sub-indicator in 0.28 and 0.49 points respectively. These generate a positive effect on the economy of South American countries. The GDP growth behavior also has an inverse relation on the macroeconomic condition sub-indicator calculated by Mohr and Wagner (2013) using a SEM model.

We find that the solvency vulnerability sub-indicator is positively influenced by total debt (% of GDP), external debt (% of GDP) and central government debt (% of GDP). Therefore, if these observable variables increase one point, the solvency vulnerability sub-indicator also increases in 0.72, 0.48 and 0.89 points respectively.²⁴

Furthermore, there is a positive relationship between the liquidity vulnerability sub-indicator and broad money (% of GDP), total reserves (% of total external debt) and liquid liabilities (% of GDP). This confirms that liquidity vulnerability increases simultaneously in 0.95, 0.53 and 0.89 points respectively, when these observable variables rise in one point. In addition, the liquidity sub-indicator shows a negatively structural relationship with the macroeconomics and market sub-indicators, since if there is a high level of liquidity, the return decreases because the investment decreases, i.e., the market risk decreases or vice versa. Whereas if macroeconomic vulnerability increases due to economic decreases, or increase in inflation, or decrease in exports; this could cause the levels of liquidity reserve to decrease.²⁵

Regarding the market vulnerability indicator, we observe it shows a positive relation with real effective rate index and price capital stock, i.e., if these observable variables increase, the market vulnerability also increases in 0.18 and 0.23 points respectively. This result can be explained as follows: i) an increase of the real effective exchange rate could cause a decrease in international competitiveness due to the fact that exports are more expensive, leading to a fall in the trade balance and ii) even though an increase of the capital stock price generates higher returns, uncertainty increases due to the volatility of asset prices. As seen in Table 3.4, there is a negative relation between the market vulnerability indicator and domestic credit to private sector (% of GDP). This explains that a decrease in domestic credit to private sector of one point, could generate an increase in market volatility of 0.98 points.

The social development vulnerability is positively influenced by mortality rate and poverty gap,

²⁴The majority of these indicator were significant in the following empirical studies: Hawkins and Klau (2000), Abiad (2003), Majardi et al. (2009) and Supriyadi (2015)

²⁵This relation is observed in the path graph of the Appendix A.3 in the figure A.3.1.

i.e., the social development vulnerability risk increases in 0.80 and 0.35 points respectively as these observable variables rise in one point. Conversely, the social development vulnerability sub-indicator shows an inverse relation with government expenditure on education, in other words, if this variable decreases in one point, the social development vulnerability increases in 0.81 points. These results can be attributed to the fact that these variables are more sensitive to face changes in public policies of the governments (for a similar line of reasoning, see Briguglio et al. (2009)). In addition, the dummy crisis variables describe that the presence of inflation crisis, as well as presence of any crisis (banking, currency and sovereign crisis), increases the MSF vulnerability index.

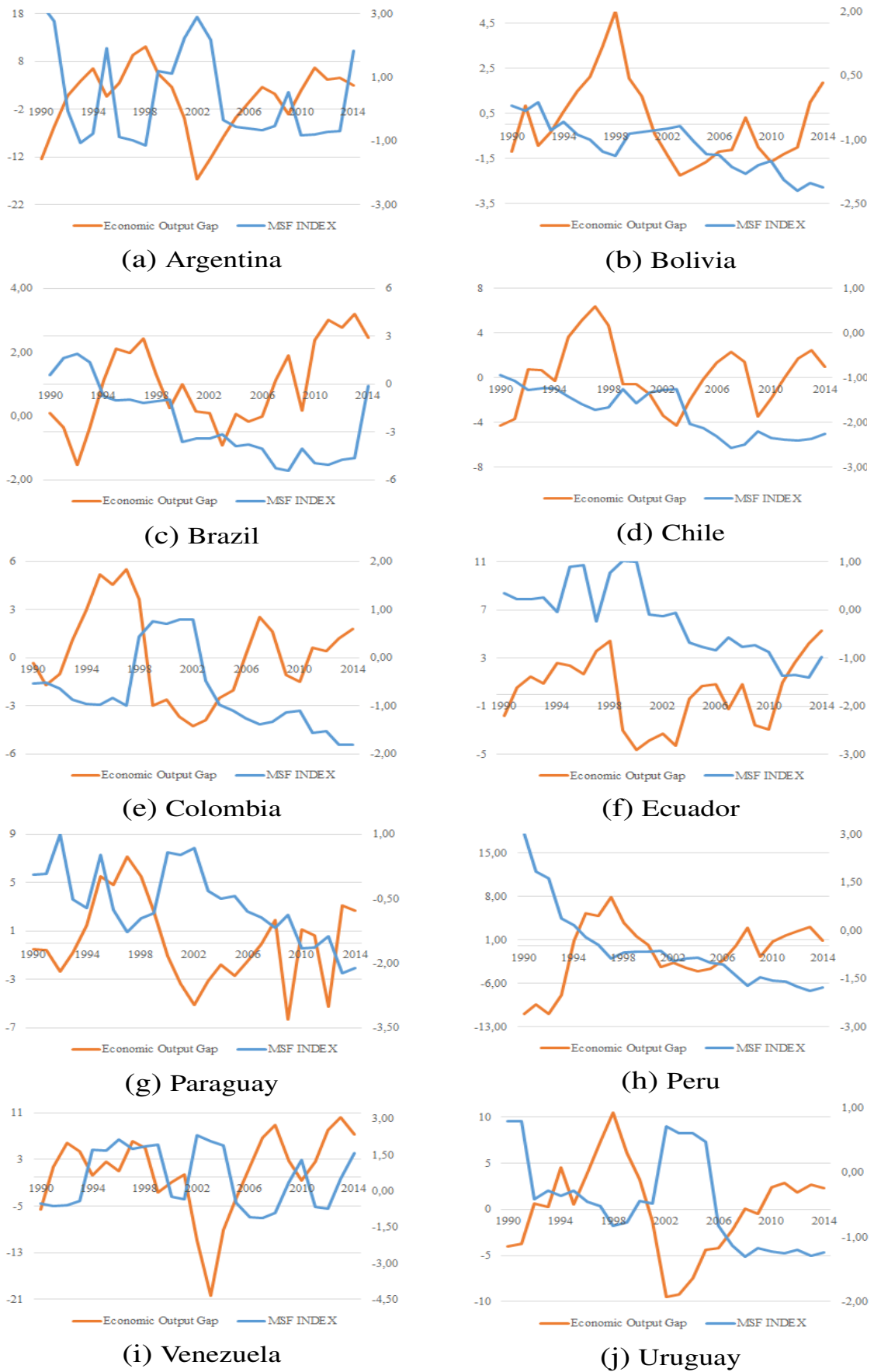
In the second construction order, there is also a formative relation between the MSF index and its sub-indicators. The MSF vulnerability index is positively influenced by macroeconomic, solvency, social development and market vulnerability sub-indicators. If these sub-indicators increase one point, the MSF index rises by 0.27, 0.15, 0.21 and 0.13 points respectively. On the contrary, an increase of one point of the liquidity vulnerability sub-indicator leads to a decrease by 0.22 points in the MSF vulnerability index or vice versa. Therefore, the lower the liquidity vulnerability sub-indicator, the higher the level of the MSF vulnerability index.²⁶

In the end, we verified that our MSF index captures the periods of vulnerability of the 10 countries analyzed, since the behaviour of the economic cycle expressed in the economic output gap indicator calculated by the Inter-American Development Bank is inversely proportional to the MSF index, i.e., when there is a decline in a country's output gap in a given period, there is a growth in the MSF vulnerability index in the same period, as seen in Figure 3.4.²⁷

²⁶The liquidity vulnerability sub-indicator has a negative influence on the MSF index, due to the fact that this sub-indicator is composed of liquid liabilities, i.e. if this variable increases, the liquidity risk increases. In addition, as mentioned above, this sub-indicator presents a structural relationship influenced by the behaviour of the macroeconomic and market vulnerability sub-indicators.

²⁷Inter-American Development Bank uses the Hodrick-Prescott (HP) filtering technique to estimate output gaps. The figures were elaborated from 1990 onward due to lack of availability of economic output gap data.

Figure 3.4. MSF index versus Economic output gap Latin American countries (points)



Source: Inter-American Development Bank and authors' MSF calculations

Table 3.5. Evaluation results for each predictive model over the test data-set

Classification Methods	Precision=0	Precision=1	Recall=0	Recall=1	F-Measure=0	F-Measure=1	Accuracy	Type I	Type II	ROC	NSR	Global Classification
LDA	0.992	0.983	0.992	0.983	0.992	0.983	0.989	0.008	0.017	0.989	0.034	0.989
KNN	0.992	0.966	0.984	0.983	0.988	0.974	0.984	0.008	0.033	0.984	0.034	0.984
SVM	0.992	1.000	1.000	0.983	0.996	0.991	0.995	0.008	0.000	0.991	0.000	0.995

Note: these ratios are evaluation measures of the predictions on the test data-set of each method.

Source: Authors' Calculations

Table 3.6. The limits of the zones of uncertainty

Classification Methods	Uncertainty threshold											
	Cut-off			SD		High Uncertainty			Low Uncertainty			
	C1 = 1	C2 = 0	C	High	Low	Unmanageable	Intolerable	Unstable	Manageable	Moderate	Stable	Strong
LDA	1.267	-0.551	0.358	0.643	0.510	1.910	1.267	0.625	-0.041	-0.551	-1.061	>-1.061
KNN	1.252	-0.558	0.347	0.648	0.505	1.900	1.252	0.604	-0.053	-0.558	-1.063	>-1.063
SVM	1.286	-0.545	0.370	0.633	0.512	1.919	1.286	0.652	-0.032	-0.545	-1.057	>-1.057

Note: these thresholds were calculated according to the predictions over the test data-set for each method.

Source: Authors' Calculations

In order to construct the thermometer of the macro-financial uncertainty, we first determined high and low uncertainty of the MSF vulnerability index by the k-means- cluster method. Second, we standardized the MSF index by the z-score. Finally, we estimated the uncertainty prediction by three classification methods in order to make a robust analysis and calculate the cut-offs and standard deviation of both high and low uncertainty. We followed the prediction classification obtained to determine the alert threshold sub-zones.

Table 3.5 reports the performance of the generated models on the test data-set.²⁸ The evaluation of the uncertainty prediction for each classification algorithm method is given by the evaluation measures mentioned in sub-subsection 3.4.2. We find that most of the measures have scores close to one, both in crisis $\bar{1}$ and non-crisis $\bar{0}$ periods. This confirms that there is a high level of precision and accuracy and also sensitivity that identifies the periods of vulnerability and non-vulnerability evidenced by the high score of the recall measure in the three methods. In the case of type I error ratio, we can confirm that there is a slight probability of incorrect rejection of a real null hypothesis; in other words, there are few periods that were classified as vulnerable (0.008 average of three methods), but which do not really have macro-financial problems. Conversely, type II error ratio confirms that there are few periods that were not detected as vulnerable (0.017 is the average of the three methods).

Furthermore, the noise to signal ratio obtained in the three methods is close to zero and in the case of SVM it is zero. This allows us to confirm that the alert thresholds must be calculated using the SVM technique, since according to Chui (2002) the lower the noise to signal ratio, the more accurately the alert thresholds can be defined.

In general, these results are consistent since the three techniques show a correct global percentage of classification (greater than 0.90 points) and the SVM method presents the highest prediction ratios.

On the other hand, to build the uncertainty thermometer, we calculated centroids to determine the cut-offs and standard deviation of both high and low uncertainty. This was made according to the binary prediction classification obtained by the three classification algorithm methods proposed, in order to establish the appropriate uncertainty sub-zone at the regional level.

Table 3.6 provides the risk sub-zones estimated from the high and low uncertainty classification prediction obtained through the classification methods. Columns 1 and 2 show the centroids of the z-score of the MSF index classified as high (c1) and low (c2) and column 3 details the mean of these centroids, known as cut-off at the regional level. In addition, columns 4 and 5 detail the standard deviation of the high and low risk level. To identify high-risk sub-zones at the regional level, we consider that centroid C1 is the intolerable sub-zone, while $C1 + \sigma$ is the unstable sub-zone and $C1 - \sigma$ is the unmanageable sub-zone. In the same line, the moderate-low risk sub-zone is C2, on the other hand, the sum between C1 and σ determines the manageable sub-zone, while the subtraction between C2 and σ indicates the limit of the stable sub-zone and the z-score of the MSF index greater than the limit of the stable sub-zone is identified as a strong sub-zone.

²⁸The evaluation results for each predictive model over the train data-set is detailed in Appendix A.4

Table 3.7. Periods of uncertainty according to the MSF vulnerability index 1978 - 2014

Countries	1978 - 2014						
	Periods - High Uncertainty			Periods - Low Uncertainty			
	Unmanageable	Intolerable	Unstable	Manageable	Moderate	Stable	Strong
ARGENTINA	82, 84-91, 01-02	78-81, 83, 95, 03, 14	99-00, 09	92	94, 04-08, 10-13	93, 96-98	
BOLIVIA	83-86	82	79-81	78, 87-90, 92	91, 93-94, 99-03	95-98, 04-06	07-14
BRAZIL		82-83, 87-88, 91-93	89-90, 95-96, 99, 14	78-81, 84-86, 94, 97-98	00-03	04-06, 09-13	07-08
CHILE			81-85	86-87	78-79	80, 88-95, 99, 01-03	96-98, 00, 04-14
COLOMBIA			99-02	82, 85, 98	78-81, 86-92, 96, 03	83-84, 93-95, 97, 04-10	11-14
ECUADOR			82-87, 89, 95-96, 98-00	79-80, 88, 90-94, 01-03	78, 81, 97, 04-09	10-14	
PARAGUAY			83-84, 89, 92, 00	82, 85-88, 90-91, 95, 01-02	79-81, 93-94, 96, 03-06	78, 97-99, 07-09, 12	10-11, 13-14
PERU	78, 83, 88-90	82, 91-92	79, 81	80, 84-87, 93-94	95-96, 98-01, 04	97, 02-03, 05-07, 09	08, 10-14
URUGUAY			83-85, 90-91, 02, 04-05	81-82, 03	78-80, 86-89, 92-01, 06	07-14	
VENEZUELA		89, 94-99, 02-04, 14	82, 84, 10	83, 09, 13	87-93, 00-01, 05, 11-12	79-81, 85-86, 06-08	78
TOTAL	20	30	51	56	92	81	40

Source: Authors' Calculations

In view of the fact that the three predictive classification methods have a high level of accuracy, we can find that the cut-offs and standard deviation present close ranges in all three methods. Therefore, the estimated sub-zones also have similar ranges as shown in table 6, but as the SVM method has a range of predictive precision between 0.99 (low level) and 1 (high level), we decide to consider its ranking results to analyze the vulnerability periods in the following subsection.

3.5.2. ANALYSIS OF THE UNCERTAINTY THERMOMETER OF LATIN AMERICAN COUNTRIES

This section evaluates the MSF vulnerability index calculated for 10 LA countries and analyzes the level of uncertainty obtained through the alert threshold estimated by the SVM classification technique, according to the behavior of the standardized MSF index.

Table 3.7 shows the sub-zones of high and low uncertainty in the period of 1978-2014. Our findings confirm that Latin America was economically vulnerable in the period 1980-1989, also known as “the lost decade” (Bértola and Ocampo, 2012), since the majority of the countries show an unstable and intolerable level of uncertainty in their MSF vulnerability index in 1982, 1983, 1985, 1988 and 1989. In Appendix A.5 is detailed the sub-indicators, the MSF index and the levels of uncertainty according to the results obtained by the discriminant analysis, KNN and SVM.

The rise of the MSF index is influenced by a high level of uncertainty on solvency, macroeconomic, liquidity and market vulnerability sub-indicators as a result of the increase of total debt (generated by the hike in interest rates), inflation, and decreases of liquid liabilities and financial markets. These results are also supported by the conclusion of Herrera and Garcia (1999), Reinhart (2010) and Laeven and Valencia (2012). In the same way, we can find that an important part of South American countries presents a high- unstable level of vulnerability at the end of the 90s. However, the level of uncertainty increases in the period 1998 -2000 as a consequence of banking crises and decline of stock prices, as in Laeven and Valencia (2012) and Ocampo (2014).

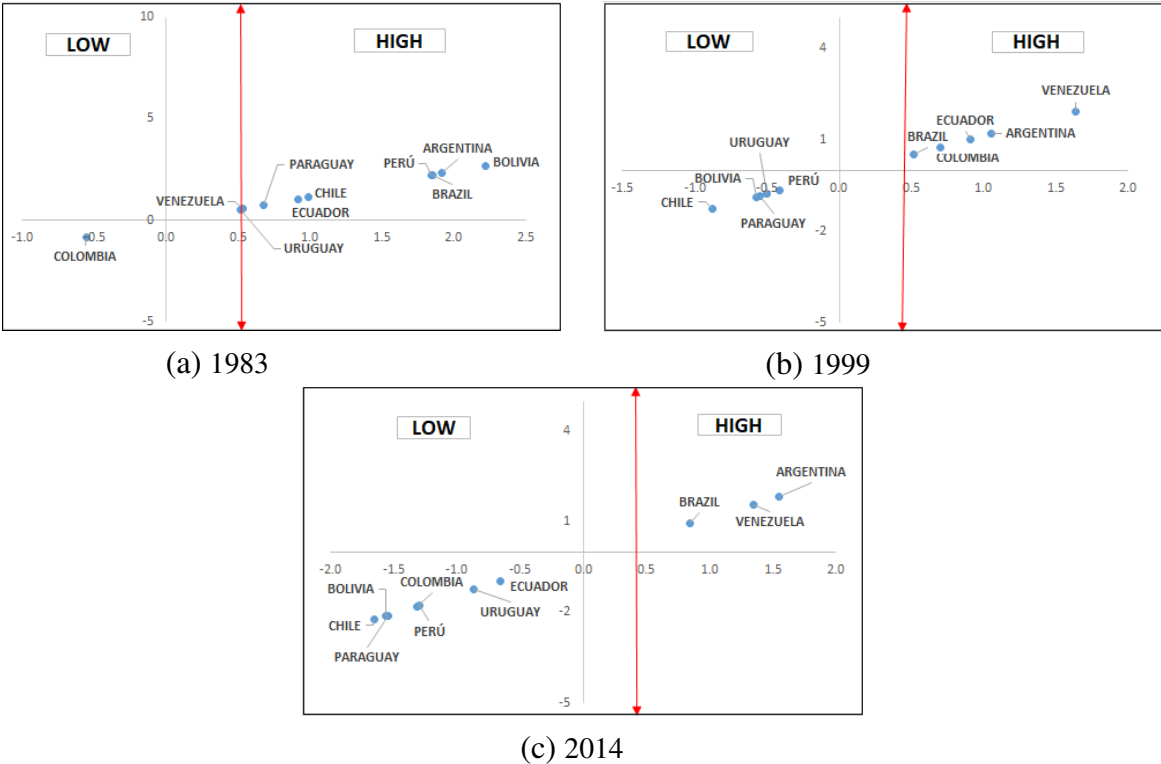
This study confirms periods of banking crisis, which were identified by Reinhart (2010), Laeven and Valencia (2012) and Bordo and Meissner (2016). We can see them in Table 7, in the case of Argentina, which shows unmanageable and intolerable periods of uncertainty in 1980, 1989, 1995 and 2001 as a consequence of liquidity and domestic lending problems. In the same way, Peru and Bolivia have an unmanageable risk in 1983 and 1996 respectively. Meanwhile, Chile, Brazil, Colombia and Uruguay present an unstable level of uncertainty in 1981, 1990, 1999 and 2002 respectively. Ecuador has an unstable level of risk in 1982, 1998-1999 and Venezuela shows an intolerable level of uncertainty in 1994.

We also find that Argentina (1999-2000), Brazil (1999), Ecuador (1998- 2000), Paraguay (2000) and Venezuela (1998-1999) show an unstable and intolerable level of risk as a consequence of the crash market (effect of the Asian crisis) and were also influenced by currency devaluation, which generated a decrease in their trade revenues. These findings are confirmed by Esquivel and Larraín (1998) and Ocampo (2014).

Furthermore, the majority of South American countries have an MSF vulnerability index with manageable, moderate and stable level of risk from 2005 to 2011, due to an improvement of the emerging financial market (rising of commodity prices, an increase in fiscal revenues, liquid liabilities (% GDP) and a decrease in poverty); except in the case of Argentina (2009) and Venezuela (2010), which present an unstable level of uncertainty.²⁹ Both countries have similar economic problems in 2014, since they have an intolerable level of risk and Brazil shows an unstable level of uncertainty as a result of a decrease in their market revenues (fall commodity prices), which produced an increase in the macroeconomic risk (rising inflation and decreased GDP), solvency risk (increased debt) and liquidity risk (decrease reserves). These results are in line with Laeven and Valencia (2012), Ocampo (2014) and IMF (2016).

Figure 3.5 describes which countries have a high or low level of the macro-social-financial risk in three periods, thus showing what was stated before.

Figure 3.5. MSF vulnerability index versus Z-score (points)



Note: The Z-score values of each country are at coordinate X and the MSF index at coordinate Y.

Source: Authors' calculations

As we can see in 1983, Bolivia and Peru present a high-unmanageable level, while Argentina and Brazil show a high – intolerable level, and Chile, Ecuador, Paraguay and Uruguay have a high-unstable level of uncertainty. On the other hand, Colombia presents a stable level of vulnerability. In 1999, Venezuela has a high-intolerable level, while Argentina, Brazil, Colombia,

²⁹The most of SA countries did not experience contractions in the period 2008-2009 (Bolivia, Peru, and Uruguay), some experienced slight contractions (Brazil and Colombia) according to Blanco (2010) and ECLAC (2011).

Ecuador have a high-unstable level and the rest of the countries have shown a moderate level of vulnerability. Finally, as we have showed before, Venezuela, Argentina, and Brazil have a high level of uncertainty in 2014, while the other Latin American countries show stable and strong levels of the macro-social-financial vulnerability.

3.6. CONCLUSIONS

This paper contributes to early warning models, since it proposes a regional systemic risk analysis at the macro level by building the Macro-Social-Financial vulnerability index (MSF). To construct such index, we consider panel data and use the PLS-SEM model, which allows to determine which indicators reflect a causal relationship on vulnerabilities: macroeconomic, solvency, liquidity, market and social development, not only through a linear regression, but through a system of equations. Furthermore, we capture the vulnerability periods according to the behavior of 10 South American economies in the period 1978 -2014 and determine the risk thresholds through predictive classification methods.

Our results are robust and consistent since each vulnerability indicator is formed by a parsimonious set of observable variables. We identify a formative effect in the first order (relationship between the observable variables and sub-indicators) and the second order (relationship between sub-indicators and the MSF index). The Macro-Social-Financial vulnerability index (MSF) is composed of three macroeconomic variables (GDP growth, inflation and export growth), three solvency variables (Total debt, external debt and central government debt), three liquidity variables (Broad money to GDP, total reserves to external debt and liquid liabilities to GDP), three market variables (Price capital stock market, domestic credit to GDP and real effective exchange rate) and three social development variables (Mortality rate, poverty gap and government expenditure on education to GDP).

Contrary to other signal methods that determine the alert threshold on a certain percentile of each individual variable that have a relationship with a crisis indicator,³⁰ we detected the sub-zone of uncertainty of the normalized MSF index at the regional level. Then, we calculated the cut-off points and standard deviation of high and low level of the risk of the three classification algorithm methods (LA, KNN and SVM) proposed as a risk monitoring mechanism at the regional level. Beyond building a vulnerability index, we confirm that the machine learning approaches can also be used to capture the uncertainty level of the economic or financial index, since both the KNN and SVM methods presented a high level of accuracy at the predictive/classification task. In view of the fact that the SVM method has a crisis precision ratio of 1, we use its ranking prediction to analyze the vulnerability periods.

The MSF vulnerability index obtained for each country captures the periods of high vulnerability in times of economic slowdowns in 1982-1985, 1988, 1989, 1995 and 1999-2002. In addition, this indicator detects that Brazil shows an unstable level of uncertainty, while Argentina presents an intolerable level and Venezuela has an unmanageable signal of uncertainty in 2014,

³⁰This is the case of Kaminsky et al. (1998), Kaminsky (1999), Chui (2002) and Supriyadi (2015).

due to a decrease of commodity prices, which directly affect the growth of these economies.³¹ In contrast to other vulnerability indicators, we also consider variables that identify social development, making our index intensify or attenuate in certain periods considering the level of poverty, mortality and investment in education in each of the countries analyzed.

This uncertainty warning thermometer is a monitoring system for ten South American countries, which identifies levels of macro-social-financial vulnerability, in order to encourage corrective macro-prudential measures to reduce uncertainty from a regional perspective. For future studies, not only will we continue to monitor macro-social-financial risk at the regional level, but we will also propose a systemic risk analysis at the micro level, that is, we will use the same methods applied to construct an index that integrates variables related to consumption, production, taxes and banking indicators for each country and we will calculate individual risk thresholds.

³¹These results are also supported by Herrera and Garcia (1999) and the crisis database of Reinhart (2010), Laeven and Valencia (2012), Ocampo (2014) and IMF (2016).

4. CHAPTER IV: Do trade and financial globalization mitigate macro-financial risk? The case of South American countries

4.1. INTRODUCTION

According to the results obtained in Chapter III, we could identify a diachronic development of the economic situation of South American countries. This regional perspective shows the interaction of social and financial scopes in order to determine levels of risk. Nevertheless, a global perspective could lead us to a better understanding of the influence of risk indicators applied to the studied region. Hence, the analysis of a possible transmission of macroeconomic and financial risk versus indicators such as trade and financial globalization could indicate a possible risk of contagion in the South American region.

It is well accepted that economic and financial vulnerability have increased in recent years. Even though it is a hard task to explain the origins of such vulnerability, stock market bubbles, currency fluctuations, banking crisis, credit contraction, high levels of external debt, fiscal deficit and external shocks are some of the factors usually believed to influence the well-being of economies (See, Claessens et al. (2014) Cardoso et al. (2014b)). Moreover, this macro-financial risk has been coupled with the evolution of globalization in several South American countries, reflected by the expansion of cross-border trade and capital flows since the mid-1980s following the great external debt. At the beginning, this commercial and financial integration was accompanied by a low-tariff exporting model, which generated an increase in economic growth of the region. But as most South American countries are characterized for having a high macroeconomic volatility, this region is exposed to greater macro-financial systemic risk generated also by the terms of trade volatility, capital flows, official exchange rate volatility and commodity prices volatility (See, Caballero (2000) and Cárcamo-Díaz and Pineda-Salazar (2014)).

In view of the fact that globalization promotes the development of mechanisms and policies of trade and financial openness, it is important to evaluate the benefits and risks that these would generate in the countries' economies. In theory, one of the advantages of trade openness is the reduction of trade barriers, which helps to reduce cost margins and boost economies of scale through access to better technologies (See, Dornbusch (1992)). Equally, it is argued that trade globalization, reduces the macroeconomic volatility and provides benefits to open economies, making markets more diversified and productive (See, Alcalá and Ciccone (2004) and Cavallo (2007)). In the same context, financial openness can also generate benefits by creating a financial interconnection through foreign capital flows driven by a regulated market and a developed, deep and stable financial system (See, Schmukle (2008) and Liargovas and Skandalis (2012)).

However, the effects of capital, technology and goods and service mobility can also carry some risks. These risks are reflected by internal or external factors which can be generated through imperfections of domestic and international markets, uncertainty in capital flows, asset price

and exchange rate volatility, cyclical movements and financial and trade cross-country linkages, which can generate direct or indirect effects on economic growth or macroeconomic volatility. The level of impact depends on the strength of trade policies and capital regulation, the degree of trade diversification and financial supervision (See, Ocampo (2000) Kaminsky et al. (2003), Ranciere et al. (2006), Schmukler and Zoido-Lobaton (2006), Galindo et al. (2007), Demirgüç-Kunt and Levine (2009) and Angkinand et al. (2010)).

Under this scenario, it seems necessary to identify the channels of transmission that could affect the economic and financial stability of South American (SA from now on) countries and, particularly, the role of trade and financial globalization as factors of macro-financial contagion risk among countries of the region. Hence, the main questions that arise in this paper are: i) Are trade and financial globalization the drivers of macro-financial systemic transmission in SA countries? and ii) Is there a macro-financial contagion risk through the interconnection of bilateral trade, economic cycle and trade agreements among the SA countries.

To this end, the main contribution of this study is to investigate the systemic effects of trade and financial globalization on the MSF vulnerability index of 10 South American countries (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay and Venezuela) from 1978 to 2014, considering three contagion channels: i) economic cycle synchronization, ii) trade flows and iii) trade agreements, using spatial models.³²

Several empirical studies have evaluated the impact of trade or financial openness on macroeconomic volatility and have found that the relationship could be causal or ambiguous (not stable over time). The causal relationship could be mixed in some cases, i.e., the effects could be positive or/and negative, depending on the nature of the shocks according to the income level of the countries or regions (See, Kose et al. (2003), Karras (2006), Drion and Adema (2011) and Sahoo et al. (2019)).

Some empirical literature has reported that trade openness has a positive effect on growth volatility due to the fact that the economies studied are exposed to external shocks (See, Kose et al. (2003) and Ahmed and Suardi (2009)). On the contrary, other studies show a negative relationship due to the fact that some economies have diversified their export basket or have increased their exports, thus reducing the production costs ex post of the crises (See, Cavallo (2007), Calderón and Schmidt-Hebbel (2008) and Sahoo et al. (2019)).

Other researches confirm that there is a positive relationship between the financial openness and macroeconomic volatility when the capital flows volatility is concentrated on a specialized production which shows volatile prices (See, Bejan et al. (2006) and Eozenou (2008)). Although, some studies demonstrate a negative impact due to the fact that the economies studied have strong regulatory on financial capital flow transactions (See, Ahmed and Suardi (2009)).

Contrary to these studies, we propose not only to identify the globalization impacts on macroeconomic volatility, but also to analyze if there is a macroeconomic-financial systemic risk and

³²We use the MSF vulnerability index, which is composed of macroeconomic, solvency, liquidity, market and social development vulnerability sub-indicators. In the data section, we detail the variables that compose this index. For more details, see Guachamín et al. (2020)

a contagion of macroeconomic-financial risk driven by trade and financial globalization, using spatial econometric techniques, focusing on the South American region. This econometric method allows to distinguish interdependence and also spillover effects by cross-sectional dependence that captures the interconnection among individuals, in our case among countries linked through shocks, which are based on bilateral trade concentration, economic cycle correlation and trade agreements. The impacts of these cross-country shocks on macro-financial vulnerability index (MSF) allow to determine if there is a macro-financial contagion risk.

In recent years, there is no evidence of spatial analysis applied to macroeconomic-financial vulnerability. There are only spatial studies that have been focused more on assessing the relationship between financial liberalization and banking crisis or financial markets turbulence in developed and emerging countries, (See, Triki and Maktouf (2012), Dell'Erba et al. (2013) and Jing et al. (2018)). These studies have analyzed the possibility of contagion by the interconnection of bilateral trade, banks' bilateral foreign claims and geographic proximity. Unlike these studies, our research also examines trade openness as an interest variable and our dependent variable evaluates both the macroeconomic and financial fragility.

Our results confirm findings of the existing literature, which analyzes the impacts of trade and financial openness on macroeconomic volatility. Regarding the first question of our study, we find that financial globalization is a channel of transmission of macro-financial systemic risk, since financial openness has a significant positive effect on the MSF vulnerability index. According to the empirical studies mentioned above, this could be due to the fact that most foreign investments are concentrated on a specialized production as commodities, which have high volatility prices.

On the other hand, we also verify that trade openness is a factor of macro-financial systemic risk, since it has a negative and significant impact on the MSF index, i.e., trade openness leads to a decrease of the macro-financial risk level. According to other empirical studies, this could be attributed to the reduction of production costs as a result of the increased diversification of its export basket, which have smoothed the ex-post shocks. Contrary to this, our results report that the macro-financial risk increases when the terms of trade volatility also rises. This could be due to the fact that most SA countries export commodities which have volatile prices.

Moreover, we confirm that an increase of other external factors such as the volatility of the official exchange rate and financial instability (dummy crisis) lead to the rise of the MSF risk index. We also find that the level of the MSF vulnerability increases due the decline of the GDP growth and financial development.

We answer the second question, based on the spatial models results – we confirm that a variation in bilateral-trade, economic cycle or trade agreements of a country i may affect the MSF vulnerability index of this country and the other country j , i.e., these interconnection leads to macro-financial contagion risk. We also verify that these three weights matrices also have a relationship with GDP per-capita volatility (alternative dependent variable). Finally, the first Durbin robustness model proposed shows that if the high-technology exports and oil price decrease, the MSF vulnerability index increases. Furthermore, the impacts of these factors allow

to determine that there is a macro-financial systemic contagion risk when the financial openness is affected by a downturn in the economic cycle and a change or dissolution of a trade agreement.

The remainder of this paper is structured as follows. In section 2 we analyze the globalization effects on macro-financial vulnerability: a literature review. Section 3 explains the empirical strategic. Section 4 describes the data. Section 5 presents the results obtained and discusses the channels of macro-financial contagion. Finally, conclusions are presented in section 6.

4.2. LITERATURE REVIEW

In this section, we analyze the main theory and empirical studies that describe the relationship between globalization and macro-financial vulnerability and possible crisis contagion. In general, these studies argue that globalization is a phenomenon of integration that drives trade and financial liberalization, which can generate benefits or cost on the global economy and can be transmitted from one to another country.

One of the most prominent changes in South American countries in the last 35 years has been the increasing economic and financial integration with the rest of the world. The stark increase in the globalization process has been coupled with a large and persistent vulnerability. These simultaneous developments suggest that vulnerability cannot be dissociated from the process of globalization.

In this perspective, it is important to consider that the costs of globalization can be associated to exposure and resilience of continuous or slow shocks that generate macroeconomics and financial vulnerabilities on the countries' economies. These vulnerabilities are the result of transmission of perturbations originated by the economic slowdown or financial fragility that can affect the development of each country and can expand from one country to another simultaneously or consecutively (See Briguglio et al. (2009), Guillaumont (2009) and Essers (2013)).

According to Lane and Milesi-Ferretti (2008), the heterogeneity in the bilateral transmissions of shocks are driven by the asymmetries between international trade and financial linkages. These linkages vary according to the behavior of cross-border capital and financial flows (financial globalization) and reduction of barriers on the free exchange of goods and service to promote trade openness (trade globalization).³³

The debate on the impact of trade and financial globalization on macroeconomic vulnerability is complex and the results could be mixed or ambiguous. The empirical strategies commonly employed are based on time series or panel data models and aim to analyze if globalization reduces international transaction costs, promotes export-basket diversification and encourages financial development. Under this perspective, Cavallo (2007) and Calderón and Schmidt-Hebbel (2008) find that an increase of trade openness lead to a decrease in GDP growth volatility. On the

³³The majority of studies measure the financial globalization or financial integration by the sum of countries' gross external assets and liabilities related to GDP. Trade openness is measured by the sum of exports and imports divided by GDP. Several researchers also use as other control variables as terms of trade (export prices to import prices). We use these indicators as independent main variables in the proposed models.

other hand, Ahmed and Suardi (2009)) identify that financial openness has a negative effect on macroeconomic volatility in South African countries, contrary to the trade openness.

Other arguments in favor of globalization point to the efficient and diversify allocate on of resources by the capital liberalization and equity market liberalization, which can boost the economic growth (See Quinn and Toyoda (2008)). On the contrary, Newbery and Stiglitz (1984) and Rodrik (1997) mention that an increase of trade market and capital flows can also increase macroeconomic volatility and make the domestic economy more vulnerable to greater external risk. In the same context, Kose et al. (2003) find that trade openness has a positive and significant relationship on volatility of the GDP growth only in the OLS model for both industrialized and developed countries from 1960 to 1999. This would suggest that if economies are more open, they are also more vulnerable to external shocks, but this study did not find a significant relationship between financial openness and macroeconomic volatility.

Other studies have focused on assessing the relationship between trade globalization and macroeconomic vulnerability, such as Bejan et al. (2006), who use data panel model found a correlation between the increase of trade openness and the increase of macroeconomic volatility of developing countries during the period 1950-2000. In the same context, Eozenou (2008) and Dabla-Norris and Srivisal (2013) report that trade openness impacts positively on output growth volatility. Furthermore, these authors also find that the effect of financial integration on GDP growth volatility is ambiguous, since there is a not significant relationship between both in the case of emerging countries. These findings are consistent with other empirical results which suggest that the impact of financial globalization on macroeconomic volatility in emerging or developing countries also depend on capital control regimes, size of financial markets, degrees of institutional quality and domestic financial development (See, Dell'Araccia et al. (2008).

Several authors analyze the crisis contagion in the globalization era. They claim that the cross-country contagion of crises is a characteristic of open economies since foreign capital movements are potentially volatile or risky and the majority of foreign competition weakens local intermediaries.³⁴ Furthermore, Stiglitz (2000), Schmukler and Zoido-Lobaton (2006) and Obstfeld (2008) argue that globalization can lead to a crisis in open economies through the imperfections in international financial market and external factors which depend to capital and trade flows. The likelihood that these transmission channels will be extended to other countries may also be increased by trade balance deficits, external and internal indebtedness, exchange rate, remittances and financial speculation. Other authors consider that that banking crises are more likely to occur in a liberalized financial system if there is no transparency, diversification and solid banking supervision regulation.³⁵

Recently, some studies analyze the regional and urban vulnerabilities through the spatial econometric models. The main advantage of these models is the incorporation of the spatially lagged endogenous variable, spatial lagged explanatory variable and/or spatial lagged error term in linear regression models. This depends of spatial autocorrelation between endogenous or exogenous variables versus spatial weight matrices, represented through cross-country shocks and

³⁴See Dornbusch et al. (2000), Forbes and Rigobon (2002), Kaminsky et al. (2003), and Pesaran and Pick (2007)

³⁵See, Griffith-Jones and Ocampo (2009) and Claessens et al. (2011)

based on geographic or economics distances, bilateral trade, financial linkages, business cycle correlation, and among others. There are spatial studies that have specifically investigated the impact between the financial openness and financial crisis. For example, Triki and Maktouf (2012) use a spatial model to assess the relationship between financial liberalization and financial stability in 40 emerging countries between 1989 and 2010. They demonstrated that financial integration increases when there is a period of crisis.³⁶ In the same context, Jing et al. (2018), analyze the propagation of financial crisis via bilateral trade, bilateral banks' foreign claims and distance channels in order to determine the interdependence effects in the pre-crisis and crisis periods for 40 countries from 2003 to 2010.

As shown, the debate related to the theoretical impact of globalization on vulnerability is far from being closed.

4.3. EMPIRICAL STRATEGY

In this section, we first explain the spatial econometric models, which identify the impacts of the trade and financial globalization on MSF vulnerability. Second, we detail the weight matrices that are interconnected by economic cycle, bilateral trade and trade agreements cross-country connection, which allow to identify if there is a contagion risk (subsection 3.1 and 3.2).

4.3.1. ECONOMETRIC MODEL

Most of the empirical studies mentioned above have evaluated the relationship of financial or commercial globalization on macroeconomic volatility using OLS and Fixed Panel models. Unlike these studies, our research proposes not only to determine if this relation exists, but also to identify whether there is a macro-financial contagion risk through cross-country connection from the South American region, linked by the economic output- gaps correlation, bilateral trade concentration and trade agreements.

In this context, we use for this study the spatial econometric techniques. Spatial econometric model is a linear regression, which adopted the spatial dependence on series or panel data. Panel data with spatial interaction is also of great interest as it enables researchers to take into account the dynamics, but also control for the unobserved heterogeneity.

The spatial models that we apply for this research are the following: i) the Spatial Autoregressive Model (SAR) that adopts a spatially lag on dependent variables, and ii) the Spatial Durbin model (SDM) which includes a spatial lag on the independent and dependent variables and /or the spatial error term. We rely on these spatial models in order to capture the spatial dependencies across countries.³⁷

We estimate these models by the generalized method of moments (GMM) estimator to deal with potential endogeneity. According to Arbia (2014), the generalized of moments (GMM) for

³⁶According to Samuelson (2004), the financial liberalization leads to greater microeconomic efficiency through the specialization of production, which causes the macroeconomic volatility paradoxically increases.

³⁷We apply the Langrange multiplier test (LM) to identify if there is a spatial lag and/or error correlation in the model.

spatial panel models are based on the spatial Cochrane-Orcutt transformations to filter out the spatial dependence by three moments conditions, according to Kapoor et al. (2007).³⁸

We assume that domestic changes in macro-financial vulnerability are also assumed to be driven by changes in the macro-financial vulnerability of a country's closest neighbours, given their correlation of economic output-gaps, bilateral trade concentration and trade agreements - economic frontiers expressed in weight spatial matrices. Following LeSage and Kelley Pace (2009), Lee and Yu (2010) and Elhorst (2014), our Spatial Autoregressive Model (SAR) model for panel data can be expressed as follows:

$$Y_{it} = \delta \sum_{j=1}^n W_{ij} Y_{jt} + \varphi G_{it} + \beta X_{it} + \alpha_i + \epsilon_{it} \quad (13)$$

Where Y_{it} is the Macro-Social-Financial (MSF) vulnerability index for each country i in each period t ($j=1,..,N;t=1,..,T$). δ is the spatial autocorrelation coefficient, which measures of contagion risk through the interaction effect expressed by $\sum_{j=1}^n W_{ij} Y_{jt}$ that reflects the connection between the dependent variables Y_{jt} , which represents the interdependence of country i with the dependent variables of countries j and the spatial weight matrix W_{ij} . In this model the spatial weight matrices W_{ij} describe the correlation of economic output-gaps correlation, trade partner flows and trade agreements connections between countries i and j . Meanwhile, G_{it} represents the main independent variables (trade and financial openness). X_{it} is the matrix of the control variables. Note that φG_{it} and βX_{it} identify the systemic risk and reflects the relationship between each independent variables and macro-financial vulnerability index of country i in period t . Finally, α_i is country-specific fixed effects and ϵ_{ij} is the common error term and it measures the idiosyncratic risk.

On the other hand, the Spatial Durbin Model (SDM) can be expressed as follows:

$$Y_{it} = \delta \sum_{j=1}^n W_{ij} Y_{jt} + \beta X_{it} + \varphi G_{it} + \theta \sum_{j=1}^n W_{ij} G_{jt} + \alpha_i + \epsilon_{it} \quad (14)$$

In contrast to the SAR model, the spatial Durbin model adds the spatially lagged independents variables. In Equation (14), θ is the spatial autocorrelation coefficient, which measures of systemic contagion risk through the relationship expressed by $\theta \sum_{j=1}^n W_{ij} G_{jt}$ which, in its turn reflects the connection between the independent variables of interest G_{jt} , which represents the interdependence of country i with the interest independent variables of countries j and the spatial weight matrix W_{ij} . LeSage and Kelley Pace (2009) show that the spatial Durbin model is robust since it also allows the covariates in country j to directly or indirectly affect the dependent variable of country i .³⁹

We consider the trade and financial openness indicators as independent variables of interest for our model (G_{it}). Furthermore, we use other macroeconomic and financial variables as control

³⁸See, Millo and A (2015).

³⁹This model has been employed to evaluate financial turbulence transmission by Bara et al. (2016) and Jing et al. (2018)

variables (X_{it}), which are detailed in the following section.

In these spatial models, the impact of globalization on the MSF vulnerability index can be expressed as direct effects when there is a variation in the variables measuring globalization of country i that affect its own MSF index vulnerability. Conversely, there is an indirect effect when the variables measuring globalization and the control variables of a country i , change in a unit, impacting on the MSF vulnerability index of a particular country j . Note also that a change in a unit of the globalization and control variables of a particular country i , will affect on the MSF vulnerability index of all neighbors j of the region, but the impact will be lower or higher according to bilateral-trade and business cycle correlation.

4.4. WEIGHT MATRICES TO IDENTIFY THE CONTAGION RISK

One crucial issue in spatial econometric is the problem of formally incorporating spatial dependence into the model. Hence, the construction of weight matrices is then important determine if there is cross-country contagion risk. To ensure the robustness of our results, we employ three weight matrices: i) economic cycle synchronization, ii) trade flows and iii) trade agreements.

The first matrix, the economic cycle synchronization, is based on the correlation matrix of the economic output-gaps of the 10 SA countries. This indicator is calculated by the Latin American Development Bank, using a the Hodrick-Prescott (HP) filtering technique.⁴⁰

The aim of this study is also to determine if there is a bilateral trade connection among the 10 LA countries and if such connection can generate a contagion risk in the region, i.e., if there is a relation among the MSF vulnerability index of the countries studied that is amplified by trade linkages. Therefore, for our second weight matrix, we use the the foreign trade matrix, EQCHANGE, provided by Couharde et al. (2017) through the Centre d'Études Prospectives et d'Informations Internationales (CEPII) for the 1976-2016 period. This foreign trade matrix is based on bilateral export and import values according the following equation:

$$W_{ii,t} = \frac{I_{i,t}}{I_{i,t} + X_{i,t}}(W_{ij,t}^{imp}) + \frac{X_{i,t}}{I_{i,t} + X_{i,t}}(W_{ij,t}^{exp}) \quad (15)$$

$W_{ij,t}^{imp} = \frac{I_{i,t}^j}{I_{i,t}}$ is partner country j 's import weights and $W_{ij,t}^{exp} = \frac{X_{i,t}^j}{X_{i,t}}$ is partner country j 's export weights, where and $I_{i,t}^j$ reports import flows and $X_{i,t}^j$ denotes export flows into the country i from country j during period t . Meanwhile, $I_{i,t}$ and $X_{i,t}$ are total imports and total exports of each country i .

The construction of our third weight matrix is based on the existence of an agreement trade and/or economic frontier among the 10 LA countries. We construct a variable that takes on the value of 1 in case of agreement, 0 otherwise.⁴¹ Finally we normalize three weight matrices to estimate the spatial models.

⁴⁰Dell'Erba et al. (2013) uses economic cycle synchronization by the correlation matrix of economic output-gaps.

⁴¹The information on the trade agreements are on the following page http://www.sice.oas.org/agreements_e.asp

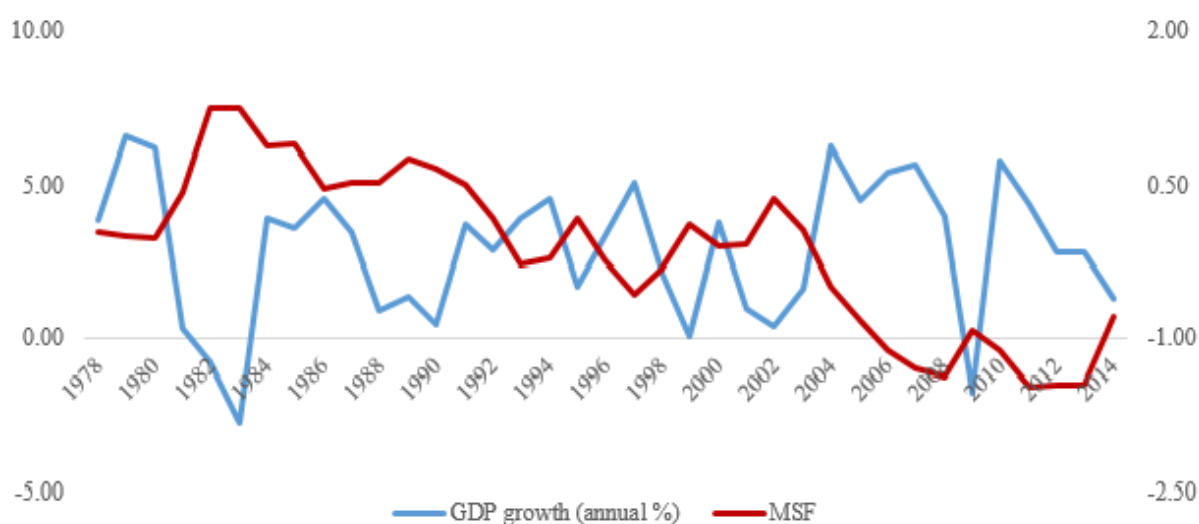
4.5. DATA

The aim of our study is to assess if the trade and financial globalization impacts directly or indirectly on the macroeconomic and financial risk of a country or region, according to connection linkages mentioned above.

Our study covers 10 South American countries, namely, Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay and Venezuela for the 1978-2014 period. Most of the variables used are available at the World Development Indicators Database by the World Bank. Additional data is available at the International Financial Statistics (IFS) by the International Monetary Fund (IMF), the Inter-American Development Bank (IADB), as well as different Central Banks.

We use the Macroeconomic-Social-Financial (MSF) vulnerability index constructed by Guachamín et al. (2020) as the dependent variable in the model proposed. The MSF vulnerability index is composed of macroeconomic, solvency, liquidity, market and social development vulnerability sub-indicators. To find the variables that are part of these sub-indicators, the author used the partial least squares structural equation model (PLS-SEM) of second order, through which it was identified, the causal relationship between the observable variables and the latent variables theoretically proposed (sub-indicators). According to the behavior of these sub-indicators and the dummy crisis variables used by other authors was built. The MSF index is composed of 5 sub-indicators, which are described in the table 4.1. The MSF index goes from high (unmanageable, intolerable and unstable) to low (manageable, moderate, stable and strong) risk level. Figure 4.1 shows the evolution of region's average MSF vulnerability index. As shown, there seems to be an inverse relationship with the average GDP growth and the MSF index.

Figure 4.1. GDP growth and MSF index (average of 10 LA countries)



Source: Authors' calculations of average of MSF index and GDP growth (annual %)

Table 4.1. Composition of MSF vulnerability index

MSF vulnerability index	
1) <i>Macroeconomic Vulnerability</i>	
	Inflation measured by the GDP deflator (annual %)
	GDP growth (annual%)
	Growth of Exports of goods and services (annual %)
2) <i>Solvency vulnerability</i>	
	Total Debt (% of GDP)
	External Debt (% of GDP)
	Central government debt, total (% of GDP)
3) <i>Liquidity variables</i>	
	Broad money (% of GDP)
	Total reserves (% of total external debt)
	Liquid liabilities (% of GDP)
4) <i>Market Vulnerability</i>	
	Real effective exchange rate
	Capital stock price,
	Domestic credit to private sector (% of GDP)
5) <i>Social Development Vulnerability</i>	
	Mortality rate, under-5 (% 1,000 live births)
	Poverty Gap \$1.90 (% of population)
	Government expenditure on education, total (% of GDP)
6) <i>Dummy Crisis Variables</i>	
	Inflation Crisis
	All crisis (banking and currency crises)

Source: World Development Indicators (WDI) - World Bank and Financial Statistics (IFS) -IMF

Table 4.2 reports the descriptive statistics of the MSF vulnerability index for the 10 SA countries. If the MSF vulnerability index decreases, the level of risk also decreases or vice versa. As seen, Chile has the lowest value of the MSF index, due to the fact that this country shows stability in the majority of periods. Contrary to Bolivia, which has high level of risk, especially in the 1980s. On the other hand, the MSF index of Argentina, Bolivia, Brazil, Peru and Venezuela show high volatility –high standard deviation– probably due to the crises or periods of instability in the 1980s and early 1990s.

Figure 4.2 describes the behavior of Macro-Social -Financial vulnerability index (MSF) of 10 LA countries in different periods 1989, 1999, 2009 and 2014. The MSF index was classified in 6 parts, where the third parts show countries with low vulnerability. More in detail, the first and second parts detail the countries that show a stable and tolerable level of vulnerability, while the third one presents the countries that have a manageable level of the uncertainty. On the other hand, the fourth, fifth and last parts indicate the countries that show an unstable level, an intolerable level and unmanageable level of risk according to the MSF vulnerability index in the periods analyzed, respectively.

Table 4.2. Summary statistics of MSF index for each country

Countries	Min	Max	Mean	Std. dev.
Argentina	-1.13	3.31	1.01	1.52
Bolivia	-2.20	3.77	-0.25	1.60
Brazil	-1.71	2.22	0.12	1.23
Chile	-2.56	1.23	-1.15	1.13
Colombia	-1.82	0.79	-0.62	0.74
Ecuador	-1.41	1.25	0.03	0.79
Paraguay	-2.23	1.17	-0.40	0.88
Peru	-1.88	3.02	0.00	1.46
Uruguay	-1.31	0.80	-0.33	0.68
Venezuela	-1.54	2.30	0.22	1.24

Source: Authors' calculations

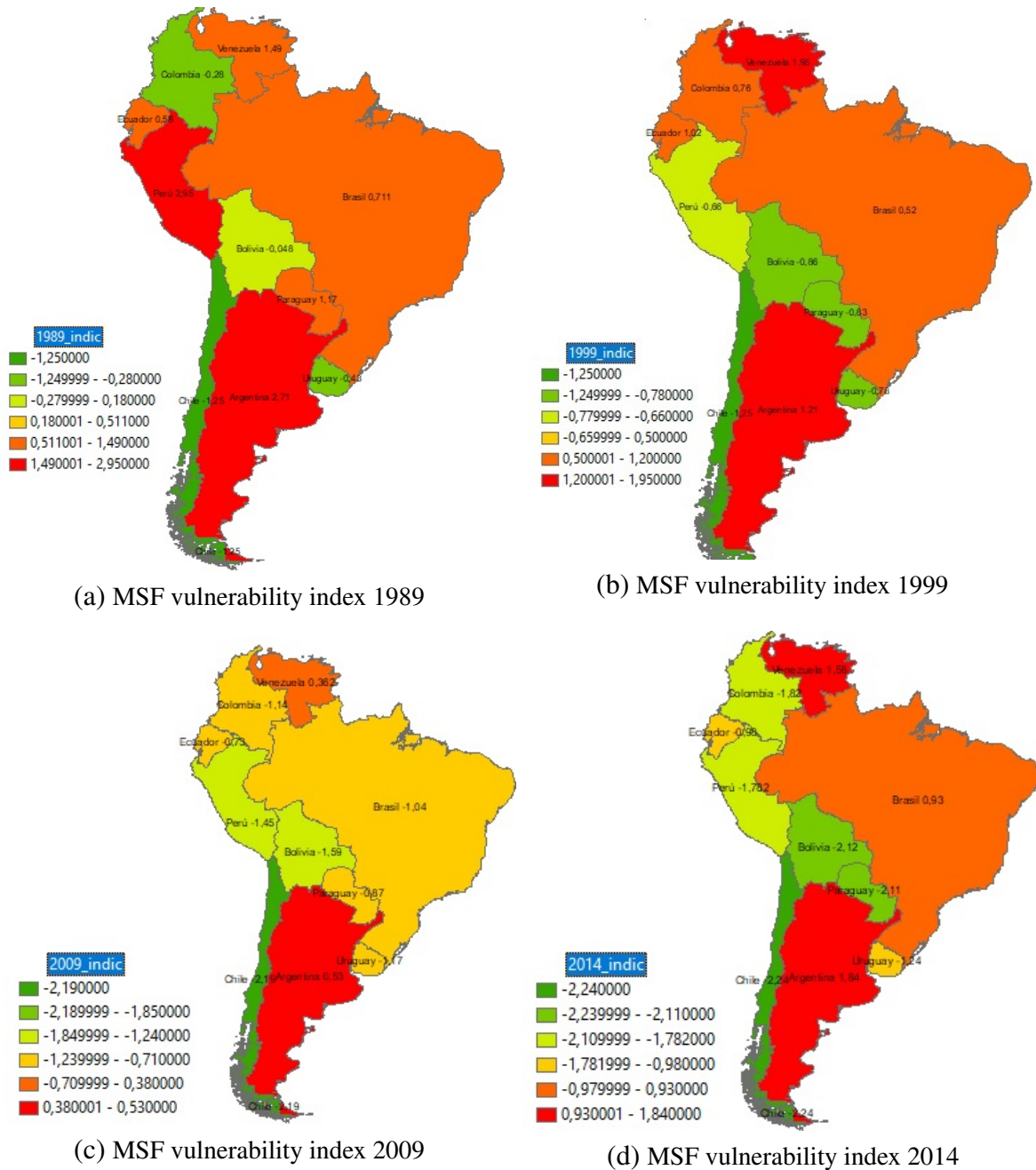
As it can be seen, Chile has a stable vulnerability level, while Colombia and Uruguay have a moderate level in 1989. The rest of the countries seemed to show unstable, intolerable or even unmanageable levels of the MSF risk in this period. On other hand, Argentina, Brazil, Colombia, Ecuador and Venezuela show a high level of uncertainty in 1999, probably as a consequences of the banking crises in this countries. In 2009, certain countries such as Bolivia and Chile have a low , while Brazil, Colombia, Paraguay, Peru, Uruguay, Ecuador present a stable and moderate level of MSF vulnerability. Finally, 2014 show intolerable and unstable levels of MSF in Argentina, Venezuela and Brazil, maybe due to the decline of commodity prices.

The goal of this study is to analyze that trade and financial globalization have a systemic impact on the Macro-Social-Financial (MSF) vulnerability index, for which, we consider, as a matter of interest, exogenous variables: i) trade openness, which is composed of the sum of exports and imports of goods and services measured as a share of GDP; ii) financial openness , composed by the sum of the stocks of aggregate foreign assets and liabilities over GDP (See, Lane and Milesi-Ferretti (2003) and Lane and Milesi-Ferretti (2006)) and iii) the evaluation of the de facto openness of an economy. With these variables, we used an alternative measure called private financial openness, defined as the sum of countries' private foreign assets and private foreign liabilities divided by GDP. The private foreign assets is composed by the subtraction between the stock of foreign assets (FA) and foreign reserves (FR), while the private foreign liabilities is composed by the subtraction between the foreign liabilities (FL) and debt assets (DA)(See, Saadma and Steiner (2016) and Graebner et al. (2018)).

On the other hand, we use as control variables the following indicators: the volatility of terms of trade, GDP growth, financial development, volatility of official exchange rate, periods of crisis (dummy banking crisis), manufactured export and the yield on 1-year of treasury bill.

We propose two models of robustness. For the first robustness model, we use the same dependent variable (MSF vulnerability index) and the two main exogenous variables mentioned above. In contrast to the main model, we evaluate the impact of other external factors, for

Figure 4.2. MSF vulnerability index of 10 LA countries in 1989, 1999, 2009 and 2014



which, we consider the following control variables: domestic credit financial sector, trade balance, high-technology exports and oil price. For the second model of robustness, we consider to the GDP per capita volatility as a dependent variable, which is used as a measure of macroeconomic vulnerability.⁴² In addition, we also use trade openness and financial openness as main control variables. To evaluate the impact of external factors, we introduce the following control variables: financial development, terms of trade volatility, official exchange rate volatility and oil price.

⁴²The macroeconomic volatility or growth volatility is the standard deviation of the log difference of real GDP per capita. This measure has been used in several studies such as Tharavanij and Piyapas (2007), Dabla-Norris and Srivisal (2013) and Bezooijen and Bikker (2017)

Finally, in order to determine if there is a risk of contagion, we evaluate the cross-country effects through the interconnection between the MSF index and the matrices linked mentioned above: i) economic cycle synchronization, ii) trade flows and iii) trade agreements.

A detailed description of the all data set is presented in the Appendix, Table 4.8. We normalize the financial and trade globalization indicators by its overall standard deviation for ease of interpretation.

Summary statistics of all variables are presented in Table 4.3. We can observe that domestic credit financial sector, oil price and GDP growth show a high standard deviation. Contrary to the terms of trade volatility, official exchange rate volatility and banking crisis dummy, which have a low volatility.

Table 4.3. Summary statistics of dependent and independent variables

Variables	Min	Max	Mean	Std. dev.
Dependent variable				
MSF	-2.56	3.77	-0.14	1.27
Growth volatility	0.00	0.13	0.03	0.02
Interest independent variables				
Trade openness	-1.63	3.51	0.00	1.00
Financial openness	-1.83	3.94	0.00	1.00
Financial openness private	-1.59	4.40	0.00	1.00
Control variables				
GDP growth (annual%)	-9.50	11.98	3.27	4.20
Financial development	-1.41	3.34	0.0	1.0
Terms of trade volatility	0.00	0.90	0.11	0.10
Official exchange rate volatility	0.00	5.37	0.28	0.29
Banking crisis dummy	0.00	1.00	0.15	0.36
Manufactured export	0.38	58.86	20.23	14.38
TB1YR (1-Year Treasury Bill)	-3.34	3.22	-0.25	1.34
Trade balance	-14.14	19.69	-0.03	3.80
Domestic credit financial sector to GDP	5.72	212.92	43.17	28.06
High-technology exports	0.10	55.23	5.39	5.26
Oil price	11.91	91.48	36.54	24.92

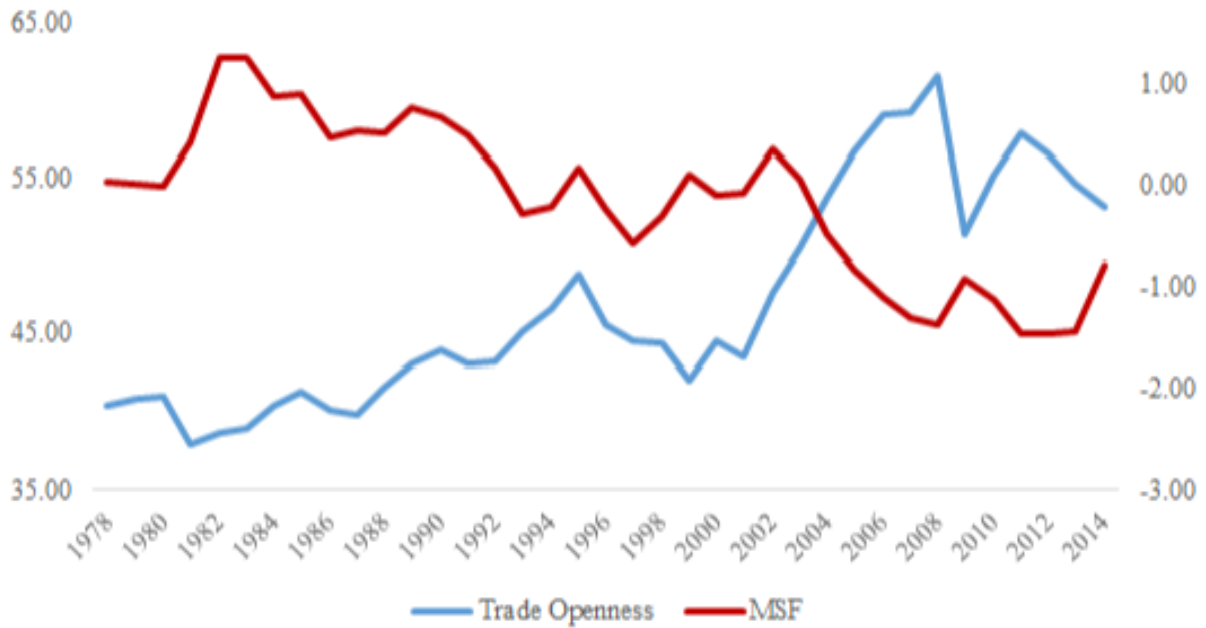
Source: World Development Indicators (WDI) - World Bank and Financial Statistics (IFS) -IMF.

Note: Variables in first difference : trade balance and TB1YR.

Note: Standardized Variables: trade openness, financial openness, financial openness private and financial development.

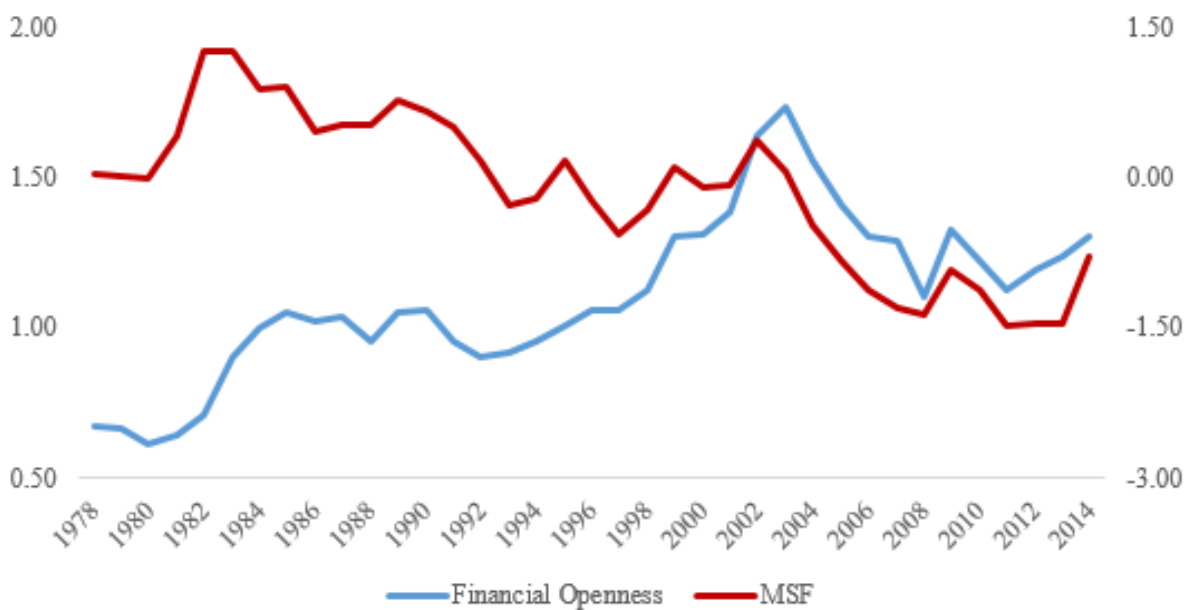
Figure 4.3 shows the evolution of the trade openness and the MSF vulnerability index from 1978 to 2014. As we have seen, there seems to be an inversely relationship between both variables, except in certain periods of the 80s and 90s. Figure 4.4, in turns, shows a similar behavior between the financial openness indicator and the MSF vulnerability index in the majority periods, i.e, if financial globalization increases due to higher capital flows and foreign direct investment, the MSF uncertainty index also augments due to the increase of yields that generate these investments. Higher yields lead to higher risk. (See Samuelson (2004)).

Figure 4.3. Trade Openness and MSF index



Source: World Development Indicators (WDI) - World Bank and author's calculations.

Figure 4.4. Financial Openness and MSF index (average of 10 LA countries)



Source: World Development Indicators (WDI) - World Bank and author's calculations.

4.6. EMPIRICAL RESULTS

This section shows the results obtained through the spatial techniques in order to evaluate if there is a systemic macro-financial risk and contagion of macro-financial risk driven by trade and financial globalization of 10 SA countries.

First, we employ a fixed effect panel model (FE) in order to identify the behaviour of the control

variables as a preliminary analysis, as detailed in Appendix, Table B.1.2.⁴³ Then, we estimate the Spatial Autoregressive model (SAR) to analyze if there is a systemic risk and contagion of macro-financial risk through the interconnected matrices proposed and the MSF vulnerability index. Moreover, we estimate the Durbin spatial model, in order to verify if there is also a systemic contagion risk derived from the relationship between the interest independent variables (trade and financial openness) and the three interconnected matrices. Finally, we estimate models of robustness.

We estimate these models with fixed spatial effects considering the results of Hausman specification test for spatial panel data models (See, appendix, Table B.1.3).⁴⁴ Therefore, we test that there is a lag spatial dependence on the three weight matrices through the Lagrange multiplier test (See appendix, Table B.1.4). We confirm there is a lag spatial dependence on the three matrices analyzed for each model proposed.⁴⁵

Table 4.4 shows the spatial estimation results of the impacts of trade and financial globalization on the MSF vulnerability index. Columns 1 refers to the results of the SAR models that evaluate the interconnection of the economic cycle. Columns 3 analyzes the bilateral trade concentration and Columns 5 shows the trade agreement connection results. SAR spatial models report results consistent, since these models confirm findings of the existing literature, which analyze the impacts of trade and financial openness on macroeconomic volatility. Furthermore, all SAR models show spatial dependence, since its respective δ have a significantly positive spatial correlation on the MSF vulnerability index, i.e, changes in economy cycle, bilateral trade and trade agreements among the 10 SA countries can lead to the macro-financial contagion risk.

Column 2, 4 and 6 report the result of the Spatial Durbin models, which also confirm that there is a contagion risk since there is a positive and significant relationship between each weight matrices and the MSF vulnerability index as obtained in the SAR models.⁴⁶ In addition, we conclude that there is no contagion of systemic risk, since there is no relationship between the independent variables of interest (trade and financial openness) and the three weight matrices, since the three spatial autocorrelation coefficients θ are not significant. This could be due to the fact that most of the SA countries have greater bilateral trade concentration and capital flows with countries outside the region such as the USA, the European Union and China (See, Ocampo (2000), Ocampo (2017)).

The most of exogenous variables are significant and show the same sign in all models. Except the yield on 1-year of treasury bill is not significant in all models.

⁴³The results of this model confirm findings of the existing literature mentioned above. Financial Openness is not significant, this ambiguous behaviour is similar to Calderon et al. (2008) (countries of low income level) and Sahoo et al. (2019) (Latin America region)

⁴⁴In the case p-value is < 0.05 , the null hypothesis is rejected - we accept the alternate hypothesis, which means that the model has spatial fixed effects.

⁴⁵The p-value is < 0.05 , i.e., the null hypotheses is rejected – there is a lag spatial.

⁴⁶These results are consistent since the three δ have a significantly positive spatial correlation.

Table 4.4. Estimation results to determine trade and financial globalization channels: Spatial models (SAR and Spatial Durbin model - Model 1)

Model 1

Dependent Variable = MSF Variables	Wec= Economy economic output-gaps correlation		Wtp= Bilateral trade partners (export and import)		Wtp= Trade agreement	
	(1)	(2)	(3)	(4)	(5)	(6)
	Spatial panel models (GMM method) SDM (only interest independents variables)		Spatial panel models (GMM method) SDM (only interest independents variables)		Spatial panel models (GMM method) SDM (only interest independents variables)	
Trade Openness	-0.305*** (0.119)	-0.291*** (0.121)	-0.324*** (0.118)	-0.306*** (0.120)	-0.318*** (0.120)	-0.269*** (0.120)
Financial Openness	0.094* (0.051)	0.144** (0.059)	0.109** (0.052)	0.146** (0.058)	0.105** (0.052)	0.183** (0.060)
GDP growth (annual%)	-0.081*** (0.010)	-0.082*** (0.010)	-0.081*** (0.010)	-0.082*** (0.010)	-0.083*** (0.010)	-0.085*** (0.009)
Financial Development	-0.493*** (0.064)	-0.484*** (0.065)	-0.504*** (0.064)	-0.487*** (0.066)	-0.480*** (0.066)	-0.462*** (0.066)
Official Exchange Rate Volatility	0.165*** (0.059)	0.171*** (0.061)	0.164*** (0.059)	0.167*** (0.061)	0.172*** (0.060)	0.176*** (0.060)
Terms of trade Volatility	0.751* (0.410)	0.682* (0.414)	0.754* (0.411)	0.747* (0.414)	0.800* (0.411)	0.702* (0.409)
Banking crisis dummy	0.948*** (0.113)	0.932*** (0.114)	0.988*** (0.113)	0.967*** (0.114)	0.945*** (0.114)	0.900*** (0.114)
Manufactures exports	-0.019*** (0.006)	-0.014*** (0.006)	-0.019*** (0.006)	-0.017*** (0.006)	-0.017*** (0.006)	-0.014*** (0.006)
TB1YR (1-Year Treasury Bill)	0.010 (0.028)	0.011 (0.029)	0.001 (0.028)	-0.017 (0.029)	0.004 (0.028)	-0.001 (0.028)
W(Trade Openness)		0.136 (0.344)		-0.040 (0.387)		-0.207 (0.272)
W(Financial Openness)		-0.179 (0.135)		-0.130 (0.135)		-0.201** (0.101)
$\delta = (W(MSF))$	0.354*** (0.071)	0.381*** (0.127)	0.302*** (0.064)	0.278*** (0.095)	0.327*** (0.107)	0.263*** (0.126)
R-squared	0.71	0.71	0.71	0.71	0.70	0.71
# obs	370.370	370.370	370.370			

Note: Robust standard errors are in parenthesis. ***: significant at the 1% level, **: significant at the 5% level, *: significant at the 10% level.
Note: Variables in first difference : manufactures export and TB1YR.

We find that financial openness is a channel of transmission of macro-financial systemic risk, since it has a significant positive effect on the MSF vulnerability index. According to the empirical literature analyzed, this could be due to the fact that the most foreign investments of these countries are concentrated in a specialized production, for example the oil, energy, coal, natural gas, metals and food, which have volatile prices in the international market.⁴⁷ The behavior of financial openness is similar to Bejan et al. (2006) and Eozenou (2008).

On the other hand, we also verify that the trade openness is also a channel of transmission of macro-financial systemic risk, since it has a negative and significant impact on the MSF index in all models, i. e., when trade openness increase, the MSF vulnerability index decrease, these findings are similar to Cavallo (2007), Calderón and Schmidt-Hebbel (2008) and Sahoo et al. (2019). According to Sachs (1985), Guidotti Pablo E. et al. (2004) and Cavallo (2007), this could happen when countries diversify its export basket, allowing them to reduce production costs and smooth ex-post shocks. Contrary to this, we find that the MSF vulnerability also rises when the terms of trade volatility increases, this could be due to the fact that commodity prices are mostly volatile. This behavior is similar to Kose et al. (2003), Eozenou (2008), Calderón and Schmidt-Hebbel (2008) and Sahoo et al. (2019).

We confirm that the level of the MSF vulnerability index increases due to reduction of the GDP growth and financial development. In addition, the results report that if there is a financial instability period (dummy banking crisis), the macro-financial risk increases. Given that, the majority of SA countries' banking systems are vulnerable to external and internal shocks.⁴⁸

We also find that an increase of the volatility of the official exchange rate that leads to the MSF risk also rises. This could be due to the fact that according to McKinnon (1973) and Tille (2008), it is important to consider that a increase of foreign capital inflows could increase the nominal exchange rate volatility in short term, especially when the flows exchanged are more bonds rather than equities.

Table 4.5 details the direct and indirect effects of spatial Durbin models from the interconnection of the three weight matrices proposed. We find that the most of the exogenous variables have direct impacts on the MSF vulnerability index. We verify that if trade openness and financial development decrease in 1 deviation stander, the MSF index risk increases in an average of 0.29 and 0.48 standard deviation respectively or vice versa. In the same way, an increase of 1 point in GDP growth and manufactures exports results in increase of the MSF risk index increases in an average of 0.083 and 0.015 points respectively or vice versa.

On the other hand, if financial openness increases 1 standard deviation, the MSF risk index also increases in an average of 0.15 points. While if the terms of trade volatility and official exchange rate volatility increase in 1 point, the MSF vulnerability index also rises in an average of 0.710 and 0.171 points respectively. In addition, if there is the possibility of a banking crisis, the MSF risk index also increases in an average of 0.93 points respectively.

⁴⁷See, ECLAC (2018)

⁴⁸This finding is similar to Eozenou (2008), Ahmed and Suardi (2009), Triki and Maktouf (2012) and Jing et al. (2018)

Table 4.5. Estimation of direct and indirect effects of Spatial Durbin Model - Model 1

Variables	Wec= economic output-gaps correlation		Wtp=Bilateral trade partners		Wta= Trade agreement	
	Direct	Indirect	Direct	Indirect	Direct	Indirect
Trade Openness	-0.292**	-0.179	-0.306**	-0.118	-0.269**	-0.095
Financial Openness	0.144**	0.088	0.146**	0.056	0.183**	0.065
GDP growth (annual%)	-0.082***	-0.050	-0.082***	-0.031	-0.084***	-0.030
Financial Development	-0.484***	-0.298	-0.487***	-0.187	-0.462***	-0.164
Official Exchange Rate Volatility	0.171***	0.105	0.167***	0.064	0.176***	0.062
Terms of trade Volatility	0.682*	0.420	0.747*	0.288	0.703*	0.250
Banking crisis dummy	0.932***	0.574	0.968***	0.373	0.900***	0.320
Manufactures exports	-0.014**	-0.009	-0.017**	-0.0068	-0.014**	-0.005
TB1YR (1-Year Treasury Bill)	0.011	0.006	-0.0001	-0.00006	-0.001	-0.0006

Note: Robust standard errors are in parenthesis. ***: significant at the 1% level, **: significant at the 5% level, *: significant at the 10% level.

In view of the fact that most foreign capital flows are private, it is important to evaluate their impact on the MSF vulnerability index, for which we estimate a spatial Durbin Model.

Table 4.6 shows the results obtained for each weight matrix proposed. As we can observe the control variables and trade openness present the same sign as the previous model.

Table 4.6. Results of spatial Durbin models - Model 2

Dependent variable = MSF	(1)	(2)	(3)
	Wec= economic cycle	Wtp= bilateral trade	Wta= trade agreement
Trade Openness	-0.256** (0.119)	-0.269** (0.119)	-0.215* (0.118)
Private Financial Openness	0.123** (0.051)	0.125** (0.051)	0.156*** (0.051)
GDP growth (annual%)	-0.082*** (0.010)	-0.082*** (0.010)	-0.084*** (0.009)
Financial Development	-0.498*** (0.061)	-0.504*** (0.066)	-0.481*** (0.066)
Official Exchange Rate Volatility	0.169*** (0.061)	0.166*** (0.061)	0.173*** (0.060)
Terms of trade Volatility	0.709* (0.415)	0.787* (0.413)	0.745* (0.409)
Banking crisis dummy	0.946*** (0.113)	0.979*** (0.113)	0.913*** (0.003)
Manufactures exports	-0.015*** (0.006)	-0.018*** (0.006)	-0.014** (0.006)
TB1YR (1-Year Treasury Bill)	0.011 (0.029)	-0.0005 (0.029)	-0.001 (0.028)
W(Trade Openness)	0.107 (0.323)	-0.052 (0.356)	-0.224 (0.259)
W(Private Financial Openness)	-0.174* (0.105)	-0.111 (0.130)	-0.199** (0.092)
$\delta = W(MSF)$	0.374*** (0.126)	0.271*** (0.094)	0.264** (0.108)
R-squared	0.71	0.71	0.71
# obs	370	370	370

Note: Robust standard errors are in parenthesis. ***: significant at the 1% level, **: significant at the 5% level, *: significant at the 10% level.

Note: Variables in first difference : trade balance.

Unlike the previous model, there is an interconnection between private financial openness versus the correlation of the economic output-gaps and trade agreements W(Private Financial Openness), i.e., a variation of economic output-gaps correlation matrix among SA countries or an change in trade agreements impact on private financial openness. These impacts generate an increase of macro-financial risk at the same time, this meaning that there is a systemic contagion risk.

In this case there is a systemic contagion risk due to the fact that private financial openness measures the private capital of an economy and exclude the official claims and liabilities, in order to investors obtain return-maximizing through the international transactions, which are more risky due to their volatility (See, Saadma and Steiner (2016)).

4.6.1. ROBUSTNESS CHECKS

This subsection reports the results obtained of robustness models proposed. These models have been estimated through the spatial Durbin model. For the first robustness model, we consider the same dependent variable and the main exogenous variables used in the previous model. Contrary to the previous models estimated, we evaluate the influence of other external factors, such as the domestic credit financial sector, trade balance, high-technology exports and oil price.

Table 4.7 describes the results of the first robustness model. We estimate a spatial Durbin model for each weight matrix: column 1–economic cycle correlation, column 2–bilateral trade connection and column 3–trade agreements.

In the three models, the trade and financial openness are significant and show the same sign than the previous model. On the other hand, if there is a decrease in domestic credit, the vulnerability of MSF risk increases.⁴⁹ The same happens, if the trade balance and high-technology exports decrease.

Table 4.7. Results of spatial Durbin models - Robustness model 1

Dependent variable = MSF	(1)	(2)	(3)
	Wec= economic cycle	Wtp= bilateral trade	Wta= trade agreement
Trade Openness	-0.313** (0.1415)	-0.362** (0.142)	-0.322** (0.143)
Financial Openness	0.199*** (0.067)	0.207*** (0.068)	0.253** (0.068)
GDP growth (annual%)	-0.109*** (0.012)	-0.110*** (0.012)	-0.111*** (0.012)
Domestic Credit Financial Sector	-0.006** (0.002)	-0.004** (0.002)	-0.005** (0.002)
Trade Balance	-0.023* (0.012)	-0.018 (0.012)	-0.022* (0.012)
High-technology exports	-0.029*** (0.010)	-0.033*** (0.010)	-0.033*** (0.010)
Oil price	-0.006* (0.003)	-0.006* (0.003)	-0.004 (0.003)
W(Trade Openness)	0.446 (0.454)	-0.109 (0.492)	-0.411 (0.361)
W(Financial Openness)	-0.300** (0.126)	-0.259 (0.160)	-0.269** (0.114)
$\delta = W(MSF)$	0.594*** (0.162)	0.289*** (0.132)	0.300*** (0.137)
R-squared	0.61	0.61	0.63
# obs	370	370	370

Note: Robust standard errors are in parenthesis. ***: significant at the 1% level, **: significant at the 5% level, *: significant at the 10% level.

Note: Variables in first difference : trade balance.

⁴⁹This result is similar to Kose et al. (2003), Eozenou (2008), Ahmed and Suardi (2009), Jing et al. (2018), Triki and Maktouf (2012) and Dabla-Norris and Srivisal (2013)

In addition, we verify that a fall of oil price leads to the MSF vulnerability index increases, due to the fact that South American countries have concentrated its exports in commodities, which are more vulnerable to external market shocks (See, Ocampo (2017)). We also find that if the high-technology export decreases, the MSF vulnerability index increases.

The introduction of these external factors and not considering the official exchange rate volatility in this model has led to financial openness being affected by the behavior of economic output-gaps and trade agreements W (Financial openness). In the other words, if there is a slow-down in the economic cycle of country i , although foreign investment has increased in this country and its neighbor j , but it has focused on a specialized production such as oil or certain technology products that have volatile prices, this could lead to the MSF vulnerability index rise in the countries i and j . Besides, if a trade agreement between country i and j is dissolved or change, in spite of the fact that foreign investment increased, this could generate an increase in the MSF vulnerability index in country i or j or in both of them. This confirms that there is also the possibility of a macro-financial systemic contagion risk.

Table 4.8 describes the second robustness model results for each interconnected matrix analyzed through spatial Durbin model. In contrast to the previous robustness model, we consider to the GDP per capita volatility as dependent variable. This indicator is used as a measure of macroeconomic vulnerability.⁵⁰ In addition, we also use trade openness and financial openness as independent variables of interest and to evaluate the impact of other external factors, we introduce the following control variables: financial development, terms of trade volatility, official exchange rate volatility and oil price.

In the specific case of financial openness, we again confirm that if foreign capital flows (financial openness) are concentrated in specialized production, as it is the case of commodity production in South America, the macroeconomic volatility also increases.⁵¹ On the other hand, the trade openness shows a negative impact similar to the previous models, although it does not present a major significance, considering this indicator does not adjust over time with the macroeconomic volatility in the spatial models proposed, since this volatility is only composed by the standard deviation of per capita GDP, which is high in certain periods of the 80s and 90s, despite the fact that several South American countries began to diversify their exports. This ambiguity coincides with the study of Drion and Adema (2011), which specifically analyzes to Latin America in the same period. Nevertheless, this study does not use a spatial analysis. In contrast to macroeconomic vulnerability, the MSF vulnerability index not only captures macroeconomic vulnerability, but also financial and social vulnerabilities, so this index has been better adjusted over time in the spatial model.

We find that the terms of trade volatility are positive and significantly similar to the two previous models. This is due to the increase of this indicator by the volatility of commodity prices, leading to a rising of the macroeconomic volatility rises. In the same context, we verify that if there is an increase in the official exchange rate volatility, the macroeconomic volatility also

⁵⁰This standard measure has been used in several studies such as Tharavani and Piyapas (2007), Dabla-Norris and Srivisal (2013) and Bezooijen and Bikker (2017)

⁵¹This result is similar to Bejan et al. (2006), Eozenou (2008)

increases under the condition of an interconnection between bilateral trade and trade agreement. Conversely, the oil price does not have a significant impact on macroeconomic volatility.

We also confirm that financial development has a negative and significant relationship on macroeconomic. Since if there is a decrease in the financial development, the macroeconomic volatility increases. These findings are similar to the first model proposed.

Table 4.8. Robust results of Spatial Durbin Models - Robustness model 2

Dependent variable = DesvStandGDPCapita)	(1)	(2)	(3)
	Wec= economic cycle	Wtp= bilateral trade	Wta= trade agreement
Trade Openness	-0.0023 (0.0029)	-0.0007 (0.0029)	-0.0021 (0.0029)
Financial Openness	0.0024* (0.0014)	0.0036** (0.0014)	0.0025** (0.0014)
Financial Development	-0.0077*** (0.0016)	-0.0075*** (0.0016)	-0.0070*** (0.0016)
Terms of trade volatility	0.063*** (0.011)	0.060*** (0.011)	0.059*** (0.011)
Official exchange rate volatility	0.0023 (0.002)	0.0034** (0.002)	0.0028* (0.002)
Oil price	0.00008 (0.00008)	0.00014 (0.00006)	0.00007 (0.00007)
W(Trade Openness)	0.0036 (0.0076)	-0.0085 (0.0082)	0.0039 (0.0064)
W(Financial Openness)	0.0020 (0.0026)	0.0037 (0.0032)	0.0016 (0.0024)
$\lambda = W(DesvGDPCapitaT)$	0.553*** (0.163)	0.387*** (0.124)	0.567*** (0.145)
R-squared	0.99	0.99	0.99
# obs	370	370	370

Note: Robust standard errors are in parenthesis. ***: significant at the 1% level, **: significant at the 5% level, *: significant at the 10% level.

We also find that the bilateral trade, economic cycle correlation and trade agreements show a significant relationship with the macroeconomic volatility, i.e., these linkages are contagion channels of macroeconomic risk.

4.7. CONCLUSION

This study contributes to the spatial empirical analysis by identifying channels of contagion risk according to the behavior of the macro-social- financial vulnerability index (MSF) and a set of exogenous variables that have a relationship with trade and financial globalization of 10 SA countries.

In contrast to other empirical literature that have evaluated the impact of trade and financial openness on macroeconomic volatility, we introduce the spatial linkages in order to determine

if there is a cross-country contagion risk according to the economic cycle synchronization (economic output-gaps correlation), bilateral trade and trade agreements by the spatial models. Furthermore, our research considers as a dependent variable an indicator, which not only identifies the macroeconomic and/or financial fragility, but both.

Our study not only identifies that the trade and financial openness are systemic transmission channels, but also verifies that the impact of financial openness is positive and significant for 10 SA countries. According to the empirical studies analyzed, this could be due to the fact that the foreign investments invest tend to tilt towards specialized productions, such as commodities that have volatile prices, increasing the level of risk. Meanwhile, trade openness has a negative and significant impact on the MSF index. This could be due to the fact that the majority of SA countries increase of its export basket diversification, which have smoothed the ex-post shocks as mentioned in studies that present the same results. Contrary to this, when the terms of trade volatility increase, the MSF vulnerability index also rise, due to exports concentrated on commodities, which have volatile prices.

The two spatial models proposed allow to verify that the economic cycle, bilateral trade and trade agreements are linkages, which influence on the MSF vulnerability index, i.e., these can generate a contagion macro-financial risk.

In contrast to other spatial models, the Durbin spatial model not only identifies if there is systemic transmission or contagion risk but also the possibility of systemic contagion risk. To identify this, we assess if there is an connection between the two interest independent variables (trade and financial openness) and each of the weights matrices in the proposed models. This relationship is reflected in the first proposed robustness model, given that by introducing external factors such as the high-technology exports and oil price, generating impacts that allow to determine that there is a systemic contagion risk, when the financial openness is affected by a slowdown in the economic cycle and a change or dissolution of a trade agreement.

This contagion risk study for 10 South American countries identifies the effects of trade and financial globalisation according to the behaviour of cross-country connection of economic cycle synchronization, bilateral trade and trade agreements. These ones allow monitor the macro-financial stability and encourage corrective macro-prudential policies in order to reduce uncertainty from a regional perspective. For future studies, we will propose to analyze the contagion macroeconomic risk considering the trade and financial openness between the South American countries and USA, China and the European Union.

5. CHAPTER V: Liquidity and monetary shocks in the face of inflation and GDP growth regimes – A non-linear approach for South American countries

5.1. INTRODUCTION

After measuring, identifying, and monitoring macro-financial contagion risk in the previous chapters, this chapter focuses on determining liquidity and monetary risk thresholds in order to monitor the macroeconomic impacts considering high and low inflation levels and economic expansion or contraction as a warning mechanism that will allow for the design of macro-prudential strategies in the region.

Since the financial crises of the 1990s, there have been reforms for supervision and risk management through the Basel Committee on Banking Supervision (BCBS) with the aim of mitigating the possibility of banking crises and the country debt overhang. However, some South American countries have experienced liquidity crisis and monetary problems at the end of the 80s and 90s as a consequence of bank instability, economic downturns and increases in debt inflation and interest rates. In addition, they experienced an economic slowdown and increased inflation during this period, which led to banking crises in countries such as Argentina, Brazil and Ecuador that also caused liquidity problems in the late 1990s and early 2000s. However, the Latin American economy showed financial stability and fiscal discipline driven by the opening of capitals and increase of commodity prices in the period of 2003 -2007 (Tovar and Quispe-Agnoli (2008) and Ocampo (2014) .

In the late 2000s, most South American economies have tried to maintain stable inflation levels as required by multilateral financing organizations, but despite this, these countries have presented monetary uncertainty linked to exchange rate and interest rate shocks. In spite of this, the financial crisis of 2009 motivated the increase in money supply as a reaction of Central Banks to an increase in inflation, due to the rise of commodity prices, accompanied with the expansive monetary policy of open economies and the high interest rate differentials, causing the exchange rate of South American countries to appreciate in 2011 and 2012. This encouraged the central banks of this region to increase interest rates and stop intervening in the foreign exchange market to reduce inflation in the region, but this had a negative impact on the region's competitiveness, since most currencies tended to appreciate in this period and their liquidity tended to adjust to the minimums (Daude and Melguizo, 2012).

According to Cavallo and Fernández-Arias (2013) liquidity crisis could be attenuated by the provision of external liquidity through international credit lines. In spite of the existence of these short-term international sources of funding, South American economies have faced restrictions on access to these credits, due to speculation caused by economic, monetary factors, political uncertainties, currency depreciation, rising inflation and interest rate, falling prices of commodities, among other factors. In the case of South American countries, the provision of

external liquidity strategy depends on the level of short-term indebtedness, payment of imports and protection for an outflow of capital (See, Luna (2015)). In addition, the credit lines have been limited during the crisis and post-crisis periods of developed countries. (See, Essers (2013) and Pham (2018)).

In general, monetary policy in South American countries depends on the dilemma of raising the exchange rate to minimize inflationary reactions or lowering the exchange rate to increase revenues from export activities. This is made more complex by the increase in benchmark lending rates, which leads to higher financial costs. Despite this, most of these countries since 2015 have chosen to keep their domestic interest rates stable so as not to affect their monetary rate in order to recover their monetary credibility, considering that many of these economies have a high volatility in foreign exchange markets, since their economies maintain high levels of investment or debt in dollars. This is the case of Colombia and Peru, which have experienced devaluations of their currencies in periods when the dollar has appreciated. On the other hand, Ecuador, being a dollarized country, cannot take monetary measures to benefit its competitiveness, but has maintained inflationary stability and its interest rates have not shown significant variations in recent years, whereas the devaluations of its neighboring countries have increased contraband and the importation of cheaper substitute goods. Meanwhile, Argentina and Venezuela have high devaluations, high inflation levels and liquid assets adjusted to high short-term debt. This was attenuated from 2019 and much more with the coronavirus pandemic crisis at the beginning of 2020 (Pérez and Vernengo, 2019), (ECLAC, 2018b) and (ECLAC, 2020).

Under this context, it is a key element to monitor monetary uncertainty and liquidity risk in the South American region considering the behaviour of certain economic and financial variables. Therefore, this study will answer the following question: How does a monetary and liquidity shocks influence the main macroeconomic indicators in the face of a high and low inflation regime and a possible expansion or contraction of the economy?

In order to answer this question, it is important to consider that in order to design macroprudential stabilisation strategies, it is necessary to determine a mechanism which evaluates the monetary and liquidity shocks on economic and financial indicators, according to the non-linear multivariate relationships, generating stress thresholds that not only capture these relationships, but also consider the behavior of inflation and GDP growth as regimes, i.e., these interactions captured at the same time, allow identifying the non-linear systemic transmission, using the threshold vector autoregressive model (TVAR) for each of the 10 South American countries for the period between 2006 Q1 and 2020Q2. These thresholds provide reference limits for stress scenarios that should be updated and evaluated through a liquidity and monetary risk monitoring system for South American countries.

Some authors have proposed studies that have evaluated the impacts of liquidity through the accumulation of the reserves according to the behaviour of GDP growth in periods of crisis through linear models (See, Dominguez et al. (2012), Dominguez (2012) and Ardanaz (2015)). On the other hand, (Weise, 1999) and (Bigio and Salas, 2008) evaluated monetary shocks on economic growth, the exchange rate and inflation through the Smooth Transition VAR model (LSTVAR) in order to identify impacts in periods of economic expansion and contraction.

In the last years, several authors have used the TVAR approach - nonlinear models to study the monetary impacts. This is the case of Shen and Chi-Nan (1999), who analysed the effect of monetary policy on interest rate according to the behaviour of two inflation regimes (low and high) In the same context, Allegret and Sallenave (2018) found that the accumulation of international reserves reduce the negative shocks on output gap, for which they considered high and low reserve holding regimes of emerging markets.

Contrary to other proposals, our study aims to determine multivariate thresholds through the TVAR method, in order to identify regimes of high and low inflation and regimes of economic contraction and expansion considering the liquid asset over short term liabilities indicator as liquidity shock and the M2 over GDP indicator as monetary shock in the face of the simultaneous behavior of inflation, GDP growth, nominal interest rate, the nominal exchange rate, bank liquid reserves to bank assets ratio percent. These impacts will be reflected through the projections of impulse response of each proposed regime as stress scenarios, which will serve as a guide for economic decision support in the South American region, considering the monetary and liquidity behaviour in the long term according to the growth or decreases of the economy, the affectations of the competitive capacity of these countries when varying the prices of goods, nominal exchange rate and nominal interest rates.

The results confirm that there is a non-linear relationship between liquidity risk measures by the indicator liquidity assets to short term liabilities and the main macroeconomic indicators, since the risk thresholds obtained are significant. Our main finding when evaluating the monetary impact through the indicator M2 over GDP growth also present a non-linear interaction in the face of GDP growth and inflation regime in most of the countries. The inflationary effect in the low regime was higher when the liquidity shock increased in Bolivia, Chile, Paraguay and Uruguay, while in Argentina and Brazil, the response of inflation to the liquidity shock was weaker in the short term. A liquidity shock on the economic growth regime has different dynamics in each country with positive and negative effects. On the other hand, the money supply has different effects among the countries analyzed, both in its behavior and in its magnitude, depending on the interactions of the variables included in the model and the regime examined. In the case of Argentina and Uruguay in the short term and Brazil in the long term, when the monetary supply increases, interest rates tend to decrease, leading to higher aggregate demand, resulting in higher inflation. On the other hand, Ecuador and Paraguay in the short and medium term, when presenting a monetary expansion, it does not have an impact on inflation, but the interest rate increases, i.e. there is a liquidity trap. In addition, Chile and Bolivia present a positive monetary shock in the face of a volatile interest rate in both the short and long term.

Our study contributes to the debate on monitoring liquidity and monetary risk through stress scenarios, which identify risk thresholds. These ones improve each country's macro-prudential policies and make early decisions considering the impact of inflationary regimes and the performance of economics and financial indicators. The monetary authorities of the South American region must choose measures to stabilise prices before devaluations due to competitiveness and interest rate variations to mitigate the effects of the coronavirus crisis.

The remainder of this study is organised as a paper, which is structured as follows. The first

section is the introduction. In section 2 we analyse the liquidity and monetary effects on macro-financial performance by a literature review. Section 3 explains the empirical strategy. Section 4 describes the data. Section 5 presents the results obtained and discusses. Finally, conclusions are presented in section 6.

5.2. LITERATURE REVIEW

In this section, we analyze the theory and empirical studies about the liquidity and monetary shocks on inflation, GDP growth, nominal interest rate and nominal exchange rate.

According to Friedman (1968), the so-called "Liquidity Effect" comprises a short-term inverse relationship between interest rates and monetary policy, being the expected inflation a channel of transmission. On the other hand, the financial accelerator theory proposed by Bernanke and Gertler (1989) indicates that, the government, businesses and households depend on external financing to generate cash flows in the economy in the short term during a recession. This liquidity shock can be affected by problems of information asymmetry, moral hazard, credit rationing and high interest rates. On the contrary, during periods of economic boom, governments, enterprises, and households can finance themselves and the impact of liquidity is lower on inflation and interest rates as economic growth takes place.

Lucas (1990) developed a standard cash-in-advance model and through a benchmark analysis identified that changes in interest rates are the result of the combination of inflation effects and liquidity effects. In the same context, Grilli and Roubini (1992) evaluated two open economies through the Lucas model to determine monetary shocks of a nominal nature, where they identified effects on both interest rates and nominal and real exchange rates. On the other hand, Grilli and Roubini (1996) carried out an analysis of liquidity models and estimated a VAR model for the G-7 countries, with the purpose of studying monetary policy shocks on exchange rates. They identified that monetary shocks lead to an appreciation of the US exchange rate, while, in the rest of the countries, the shock leads to a depreciation of their national currency. Furthermore, these authors identified that a monetary contraction is associated with a transitory appreciation of the exchange rate and a temporary slowdown of the economy.

On the other hand, Weise (1999) studied the asymmetric relationships arising from monetary shocks of different sign and size during periods of economic expansion and contraction using a Logistic Smooth Transition VAR (LSTVAR) model for the United States. The author identified that when there is a contraction in the economy, a negative monetary shock produces a larger contractionary effect than when the economy is expanding. Furthermore, this study shows that a monetary shock has a large effect on the price level regardless of the initial state of the economy. In this context, Bigio and Salas (2008) also developed a Smooth Transition VAR (LSTVAR) model to study the nonlinear effects of changes in the monetary policy stance and the real exchange rate on inflation and output for Peru. This research showed that monetary policy shocks have a greater impact on economic growth during periods of recession compared to periods of high economic growth, with the opposite occurring for inflation. In addition, these authors identified that a monetary shock causes an increase in the exchange rate, which is

greater when the economy is in a period of economic growth.

Baumeister et al. (2008) show that a liquidity shock causes an increase in economic growth, as well as an increase in asset prices, and, hence, causes inflation to rise in the Eurozone. However, they point out the importance of identifying the source of the shock and the state of the economy. Thus, they indicate that the effects on economic activity and inflation are larger when the source of the shock is an increase in M1 compared to when the source of the shock originates in M2. Similarly, the impact of a liquidity shock is greater when the economic scenario is characterized by an extreme state of asset prices, i.e. during asset price booms or busts, but also during a credit boom, when the business cycle is in recession or when the monetary policy orientation is restrictive.

Some empirical studies find that the increase in liquidity is reflected during periods preceding a crisis in order to mitigate negative impacts and could improve growth performances in the post-crisis period, but this will depend on the macro-financial performance of each country (See, Dominguez et al. (2012), Catão and Milesi-Ferretti (2014), Ardanaz (2015) and Bussière et al. (2015)).

In the case of private banks with liquidity problems, the central banks would act as a lender of last instance and would implement monetary policies to prevent their reserves being reduced, identifying liquidity risk thresholds. In this context, Shen and Chi-Nan (1999) developed a TVAR model for measuring the monetary shocks on interest rate according to the behaviour of two inflation regimes. They used a multivariate framework to estimate the effect of non-borrowed reserves (NBR) and M1 growth on interest rate, output, price level and inflation (low and high regimes). This research concluded that interest rate had an inverse effect on increased monetary growth in low inflation regime and positive effect to increased monetary growth in high inflation regime.

In the same context, Caggiano et al. (2018) developed a nonlinear analysis represented by a TVAR model to identify the existence of "liquidity traps" in crisis episodes such as the Great Depression and the Great Recession (2008 international financial crisis) in the United States. A liquidity trap is a phenomenon in which expansionary monetary policy loses the ability to influence the price level and is unable to stimulate economic activity. The liquidity trap occurs when interest rates are close to 0 and prices are extremely high. For this reason, the authors use the Dow Jones stock index as a threshold variable to be able to discriminate between "speculative" periods (Great Depression and Great Recession) and "normal" periods. They found that liquidity shocks negatively and significantly affect interest rates in normal periods. While, in speculative periods, the effect of a liquidity shock is significantly different from 0 on interest rates. Thus, this study provided empirical evidence on the existence of liquidity traps in times of crisis.

In the last years, most of the studies have focused on the effects of the accumulation of international reserves to lessen the negative consequences of a financial crisis. According to Allegret and Sallenave (2018), most of the emerging countries analyzed in their study have accumulated reserves so that their economies can withstand economic and financial shocks. This research

focused on analyzing the relationship between foreign reserves and macroeconomics shocks in two periods 1995-2003 and 2004-2003, using a non-linear TVAR model, considering two regimes, one of high reserve economies and the other of low reserve detention. They evaluated three types of macroeconomics shocks; commercial, monetary and financial and they found that reserves holding mitigate negative impacts of external shocks on the output gap of the emerging markets.

On the other hand, Djebali and Zaghoudi (2020) considered the effects of both liquidity and credit risks on banking stability focusing on banks belonging to countries of the MENA region. The authors demonstrated there was a non-linear relationship between both types of risk and banking stability, represented as the Z-Score measure (Laeven and Levine (2009)). By using the Panel Smooth Threshold Regression (PSTR) model developed by Gonzalez et al. (2005), they determined two thresholds above which bank stability is affected; a 13.16% for credit risk (non-performing loans to total loans) and a 19.03% for liquidity risk (liquid assets to total assets).

Another approach that used the TVAR model is the Landgren and Crooks (2020) research about the financial stress in the Chinese economy. The authors built a financial stress index that measured the banking sector, stock market, foreign exchange rate and debt. They studied “the non-linearities in the transmission of financial stress in the Chinese system”. Landgren and Crooks (2020) performed a two-regime TVAR approach, in which the dependent variable was a vector composed of the GDP growth, inflation, interest rate and the financial stress index. The purpose of the study was to identify if there was a relationship between the conditions of the Chinese economy and the fiscal sector. They determined that the financial stress behaviour followed a cycle and they concluded that a fiscal shock had a negative effect on the Chinese economy, reducing the GDP growth.

Most of South American countries suffered from banking crises in the late 1990s. This led to a decrease in bank reserves, causing liquidity problems. In addition, the lack of liquidity of the countries was aggravated due to increases in interest rates and inflation. Whereas, at the beginning of the global financial crisis in 2008, the South American economies showed decreases in foreign investment, but the increase in commodity prices did not prolong the lack of liquidity.

Given the fragility of the monetary and liquidity system in most South American countries, it is necessary to define the exposure to liquidity and monetary risk, developing liquidity and monetary stress thresholds as a monitoring system, which help governments to take some actions to minimize economic or fiscal deficit problems. For this reason, our study focuses on the construction of a regional liquidity and currency risk stress system. Our contribution is to identify liquidity and monetary shocks on economic and financial indicators, considering a regime of high or low inflation and GDP growth, using a non-linear approach through TVAR models.

5.3. EMPIRICAL STRATEGY

In this section, we explain the non-linear TVAR methodology, which identifies stress thresholds for liquidity and monetary shocks on economic and financial indicators considering a high and low inflation regime and low (contraction) and high (expansion) economic growth.

5.3.1. THRESHOLD MODEL

TVAR models has two key features that allows us to achieve the purpose describe. In other hand, this kind of models does not require linearity assumptions, meaning that it let us capture asymmetry in reactions facing a shock. It also means that impulse response functions are also not linear. This feature is relevant because we want to distinguish the effects of a shock in each regime defined. The second key feature is that the regime that defines the regimes can be included as an endogenous variable in each VAR model since, after a shock, we must seek for switches between these.

Furthermore, our study allows us to determine the liquidity and monetary risk stress thresholds considering the effects of high or low inflation regimes, since South American economies are sensitive to changes of inflation, which are caused by monetary factors in most cases. In addition, we use the GDP growth indicators as a regime variable since the level of liquidity depends on the economic growth of the countries and the economic situation also reflect the monetary decisions. This type of approach analyzes the interaction between the variables separating the data into two regimes. An aggregate feature of the TVAR model is the non-linear impulse response function that it gives. Mathematically, it can be expressed by the equation below:

$$Y_t = \alpha_0 + \delta_1(L)Y_t + \tau_{1t} + [\alpha_1 + \delta_2(L)Y_t + \tau_{2t}] I(\pi_{t-d} > \theta) \quad (16)$$

Where Y_t is a vector of the endogenous variables, which are Liquid asset to short term liabilities index analyze the liquidity shock and the M2 ratio over GDP use to evaluate the monetary shock. To evaluate macroeconomic shocks use the following variables: GDP growth, Inflation, Nominal Real Exchange Rate, and financial variables such as Nominal Interest Rate and the ratio of bank liquid reserves over total bank assets. Meanwhile, τ_{1t} and τ_{2t} are vectors of orthogonal shocks; I is an indicator function regime that takes values of 0 or 1, the I is equal to 1 when $\pi_{t-d} > r$ and this is 0 when $\pi_{t-d} < r$, where d is lagged parameter of the threshold variable π_t and θ is the threshold value at time $t - d$. Moreover I is the deterministic regressor, which also changes when the regime switches. $\delta_1(L)$ and $\delta_2(L)$ are lag polynomials which are the coefficients of TVAR model. This model allows to identify a dynamic response of the macroeconomic indicators to change if the inflation variable exceeds a critical threshold value r . In addition, the asymmetric effect of liquidity indicator on macroeconomics shocks during the high and low inflation regime can be determined by the coefficients δ_1 . This specification is a variant of the one proposed by Balke (2000) and Li and St-Amant (2010).

5.3.2. HYPOTHESIS TESTING

Since this kind of models does not require linearity or stationarity, we must contrast if indeed there is evidence of a regime wise structure of macroeconomic behaviour. In order to do that, first we contrast the non-linear behaviour of the variables to verify which can be evaluated through regimes, or in a linear VAR model. This also helps us to determine the number of regimes. We used the test proposed by Hansen (1996) and Lo and Zivot (2001). This test is expressed by LR test statistic, which evaluates the co-variance matrix of each model, where model 0 is the simple VAR model (under the null of linearity) and model 1 is the TVAR model with one and two regimes, respectively. To determine the p-value use the bootstrap distribution based on the residuals from the null model. The null hypothesis of linearity ($m = 1$ regime) against the alternative of non-linearity ($m = 2, 3$ regimes).

5.3.3. VALIDATION

Since the model realize a grid sear to find the critical value for the threshold variable, some tests are realized in order to find the best non linear model defined in a regime wise structure. After estimating the model for each country, we proceeded to perform the jointly significance test in order to explore the nonlinear relations among the variables. For this purpose we used the Wald test, considering the p-values < 0.05 , the same way as proposed by Hansen (1996).

5.3.4. NONLINEAR RESPONSE IMPULSE FUNCTIONS

Potter (1994) and Koop et al. (1996) had identified some key differences between linear and non-linear models. First, in a non-linear model, as the one implemented in this paper, the impulse response functions cannot be derived from the coefficients of the model as in the linear variant. Also, the variance and covariance matrices change its structure in each regime. As we said, a shock can led to a switch between regimes. These authors have coped this issue to a non-linear model, defining the impulse response function as a difference between the forecasted path of each variable in presence and absence of the shock of the interest variable. This specification is given by the following equation:

$$Y_{t,j}(k, \rho_t, \Omega_{t-1}) = E[Y_{t+k} | \rho_t \Omega_{t-1}] - E[Y_{t+k} | \Omega_{t-1}] \quad (17)$$

$E[Y_{t+k} | \rho_t \Omega_{t-1}] - E[Y_{t+k} | \Omega_{t-1}]$ are conditional expectations, Ω_{t-1} where is the information viable, given in the model before the shock. $Y(t + k)$ is the value of the endogenous variable at horizon; $k\rho_t$ is the magnitude of the shock. To obtain the non-linear impulse response, it is necessary to simulate randomly the shocks ρ_{t+j} and the model conditional on initial condition Ω_{t-1} until eliminating some asymmetry that could arise the variation in the draw of ρ_{t+j} , where j is defined by the length of the endogenous variables vector.

5.4. DATA

The aim of our study is to build a stress system, which identifies the liquidity and monetary effect on economic and financial indicators considering stress scenarios through high or low inflation and GDP regimes, using the threshold vector auto regressive model (TVAR). Our study covers 10 South American countries; Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, and Venezuela for the period between 2006 Q1 and 2020 Q2. Most of the variables used are available at the International Financial Statistics (IFS) by the International Monetary Fund (IMF), the Inter-American Development Bank (IADB), and different Central Banks. Additional data is available at the World Development Indicators Database by the World Bank.

This study focuses on the evaluation of monetary shocks using the M2 ratio over GDP as the endogenous variable, and the indicator of liquidity assets over short-term liabilities as the endogenous variable to analyze the liquidity shock. On the other hand, the behaviour of economic variables such as GDP growth, Inflation, Nominal Real Exchange Rate, and financial variables such as Nominal Interest Rate and the ratio of bank liquid reserves over total bank assets according to the impact generated by their relation with the monetary or liquidity indicator, considering a high and low inflation and GDP growth regimes.

Table 5.1 shows the descriptive statistics. We can observe that inflation, real exchange rate and liquidity assets to short term liabilities indicators show a high standard deviation in the majority of countries, contrary to bank liquid reserves to bank assets and real interest rate.

Table 5.1. Descriptive Statistics

Variable	Country	Maximum	Minimum	Mean	St deviation
GDP growth	Argentina	4,40	-15,90	0,09	2,93
	Bolivia	16,34	-11,49	1,67	8,47
	Brazil	2,50	-9,20	0,27	1,78
	Chile	3,30	-13,10	0,53	2,15
	Colombia	2,40	-14,80	0,52	2,19
	Ecuador	3,20	-10,60	0,47	1,81
	Paraguay	11,60	-14,86	0,81	5,84
	Perú	8,84	-22,39	0,69	5,32
	Uruguay	10,48	-10,21	3,49	3,27
	Venezuela	10,05	-23,74	-0,91	10,06
Inflation	Argentina	5,76	3,13	4,03	0,77
	Bolivia	4,65	3,96	4,39	0,21
	Brazil	5,05	4,32	4,69	0,24
	Chile	4,65	4,17	4,44	0,14
	Colombia	4,66	4,09	4,39	0,16
	Ecuador	4,66	4,25	4,52	0,14
	Paraguay	4,67	4,03	4,41	0,19
	Perú	4,90	4,50	4,71	0,13
	Uruguay	5,38	4,27	4,81	0,33

Table 5.1 continued from previous page

Variable	Country	Maximum	Minimum	Mean	St deviation	
Liquid assets overshoot term liabilities	Venezuela	20,67	4,26	7,38	4,01	
	Argentina	69,90	40,80	49,21	7,02	
	Bolivia	85,07	40,76	60,25	10,51	
	Brazil	265,35	149,90	207,85	30,72	
	Chile	31,08	17,76	20,35	1,93	
	Colombia	50,98	37,05	42,00	2,96	
	Ecuador	43,78	26,91	34,48	4,06	
	Paraguay	37,57	15,86	22,56	4,78	
	Perú	49,01	21,35	35,84	8,01	
	Uruguay	68,39	39,73	51,93	5,46	
	Venezuela	64,15	21,23	34,28	10,15	
Bank liquid reserves over bank total assets	Argentina	50,31	24,00	31,72	6,16	
	Bolivia	36,25	11,92	24,06	6,82	
	Brazil	32,42	18,47	26,63	3,36	
	Chile	15,04	8,89	11,24	1,91	
	Colombia	8,62	5,70	7,01	0,90	
	Ecuador	12,62	0,37	6,33	2,62	
	Paraguay	64,94	24,22	33,55	10,50	
	Perú	49,68	16,35	36,12	9,07	
	Uruguay	40,91	25,87	34,86	4,27	
	Venezuela	83,63	34,48	45,51	7,51	
	Nominal Exchange rate	Argentina	69,54	3,04	13,47	16,71
Bolivia		8,00	6,84	7,09	0,35	
Brazil		5,48	1,00	2,51	1,10	
Chile		841,23	441,92	582,98	92,51	
Colombia		3897,36	1733,04	2417,42	589,88	
Paraguay		6711,13	3960,48	5096,29	724,80	
Perú		3,50	2,57	3,06	0,27	
Uruguay		43,28	18,48	25,48	5,94	
Venezuela		143820,00	2,15	5551,52	24071,09	
Nominal interest rate		Argentina	0,70	0,06	0,19	0,13
		Bolivia	0,07	0,00	0,02	0,02
	Brazil	0,09	0,02	0,07	0,01	
	Chile	0,09	0,00	0,04	0,02	
	Colombia	0,10	0,04	0,06	0,02	
	Ecuador	0,06	0,04	0,05	0,01	
	Paraguay	0,11	0,02	0,06	0,02	
	Perú	0,04	0,00	0,03	0,01	
	Uruguay	0,07	0,02	0,04	0,01	

Table 5.1 continued from previous page

Variable	Country	Maximum	Minimum	Mean	St deviation
M2 over GDP	Venezuela	0,24	0,10	0,15	0,03
	Argentina	8,44	0,28	1,77	1,83
	Bolivia	16,38	1,40	8,87	4,40
	Brazil	13,58	2,50	5,35	2,25
	Chile	4,59	1,35	2,56	0,78
	Colombia	0,00	0,00	0,00	0,00
	Ecuador	3,76	0,38	1,85	0,82
	Paraguay	1,23	0,23	0,64	0,23
	Perú	2,72	0,37	1,06	0,42
	Uruguay	2,30	0,43	1,09	0,46
	Venezuela	1362009,52	0,65	61573,21	247486,75

5.5. EMPIRICAL RESULTS

This section illustrates the results obtained, which identify the liquidity and monetary shocks on economic and financial indicators, considering to stress scenarios through a high or low inflation and GDP growth regimes, using the threshold vector autoregressive model (TVAR) non-linear model in South American countries for the period between 2006Q1 and 2020Q2.

Before determining the uncertainty thresholds of liquidity and monetary risk, we proceeded to identify if the proposed variables present a non-linear behaviour and evaluated if it is possible to execute 2 or 3 regimes through the LR test mentioned above. Table 5.2 below shows the variables that present non-linear behavior and can therefore be evaluated considering 2 or 3 regimes. These variables are inflation and GDP growth, which present a p-value lower than 0.05 in both regimes in most of the countries studied. In the case of Colombia, there is no nonlinearity and the presence of 2 or 3 regimes for inflation and GDP growth. In the same context, Peru and Paraguay do not present a non-linear relationship, and shows the presence of 2 or 3 regimes in GDP growth.

Table 5.2. Test of nonlinearity - Hansen

Country	Variable	P-value Two Regime	P-value vs Linear VAR	P-value 2 vs 3 regime
Argentina	GDP growth	0	0	0
Argentina	Inflation	0	0	0
Bolivia	GDP growth	0	0	0
Bolivia	Inflation	0	0	0
Brasil	GDP growth	0	0	0
Brasil	Inflation	0	0	0
Chile	GDP growth	0	0	0
Chile	Inflation	0	0	0
Colombia	GDP growth	0,3	0,1	0,9
Colombia	Inflation	0,2	0,1	0,5
Ecuador	GDP growth	0	0	0,3

Table 5.2. Test of nonlinearity - Hansen

Country	Variable	P-value Two Regime	P-value vs Linear VAR	P-value 2 vs 3 regime
Ecuador	Inflation	0	0	0,1
Paraguay	GDP growth	0,1	0,7	0,7
Paraguay	Inflation	0	0	0,3
Perú	GDP growth	1	1	0,4
Perú	Inflation	1	1	0
Uruguay	GDP growth	0,2	0	0
Uruguay	Inflation	0	0	0
Venezuela	GDP growth	0	0	0
Venezuela	Inflation	0	0	0

Table 5.3 details the results of Wald statistic and threshold of each country in each inflation and GDP growth regimes, where confirm that most of the countries have a significant nonlinear relationship among the inflation and GDP growth. This test allows us to identify the threshold for both an inflation regime and GDP growth. To evaluate if these thresholds are significant, we evaluate of three types of Wald test were evaluated: Best Wald, Sup-Wald (maximum Wald statistic over all possible threshold values) and Avg- Wald (average Wald statistic over all possible threshold values). In the case of Colombia, it was identified that the threshold for GDP growth is not significant, so no reference threshold was obtained for this country. The graphs describing the inflation regime and GDP growth thresholds obtained for each country through the Wald test are shown in the subappendices C.1.1 and C.1.3

Table 5.3. Nonlinearity Estimated threshold and Wald test

Country	Regime Variable	Estimated threshold	Best Wald	Sup Wald	Avg Wald
Argentina	GDP growth	0.30	5.83 (0.02)	10.10 (0.00)	3.78 (0.21)
Argentina	Inflation	4.89	16.24 (0.00)	16.24 (0.00)	2.19 (0.56)
Bolivia	GDP growth	113.85	11385 (0.00)	11385 (0.00)	32.39 (0.05)
Bolivia	Inflation	4.22	2.66 (0.1)	10.66 (0.00)	1.62 (0.52)
Brasil	GDP growth	1.70	3.02 (0.08)	3.02 (0.08)	1.39 (0.31)
Brasil	Inflation	4.44	8.36 (0.00)	16.32 (0.00)	3.37 (0.29)
Chile	GDP growth	-0.20	40184 (0.00)	40184 (0.00)	53883 (0.06)
Chile	Inflation	4.34	3.00 (0.08)	8.26 (0.00)	1.57 (0.35)
Colombia	GDP growth	0.80	1.00 (0.32)	1.44 (0.23)	0.62 (0.51)
Colombia	Inflation	4.41	5.76 (0.02)	5.76 (0.02)	3.35 (0.09)
Ecuador	GDP growth	0.74	5.12 (0.02)	82.39 (0.00)	4.40 (0.27)
Ecuador	Inflation	4.38	3.05 (0.08)	27.54 (0.00)	5.63 (0.14)
Paraguay	GDP growth	-2.80	3.05 (0.08)	27.54 (0.00)	5.63 (0.14)
Paraguay	Inflation	4.24	3.05 (0.08)	27.54 (0.00)	5.63 (0.14)
Perú	GDP growth	-3.74	3.05 (0.04)	27.54 (0.02)	5.63 (0.32)
Perú	Inflation	4.75	4.13 (0.04)	5.17 (0.02)	1.96 (0.32)
Uruguay	GDP growth	2.00	3.75 (0.05)	3.75 (0.05)	0.91 (0.48)
Uruguay	Inflation	4.51	5.40 (0.02)	5.40 (0.02)	1.34 (0.41)
Venezuela	GDP growth	-3.76	2.89 (0.09)	2.95 (0.09)	0.77 (0.54)
Venezuela	Inflation	5.99	4.92 (0.03)	12.20 (0.00)	8.33 (0.01)

*Standard deviation in parentheses

Considering the results of the non-linearity tests, the following TVAR models were proposed, as detailed in subappendices C.1.2, C.1.3, C.1.4 and C.1.5. The results confirm that there is a nonlinear relationship between liquidity risk measures by the indicator liquidity assets to short term liabilities and the economic and financial indicators in the face of inflation and GDP regimes, since the risk thresholds obtained are significant. In the majority South American countries the GDP growth increases, and liquid assets to cover short-term debt also increases. A non-linear interaction occurs when inflation increases, and liquid assets increase to cover short-term debt under the high and low inflation regime in some countries. The nominal interest rate and of the exchange rate present a positive liquidity shock in most countries, but this depends on the state of the economy at the time of the shock. In the other hand, when evaluating the monetary impact on economic and financial indicators, considering there are nonlinear relationship in the face of GDP growth and inflation regimes, we find that the money supply increases, interest rates tend to decrease, causing a higher aggregate demand that is later translated into higher inflation; this was the case of Argentina and Uruguay in the short term and Brazil in the long term. These results will be detailed in depth in the following impulse response analysis, considering their short and long term responses.

5.5.1. INFLATION REGIME WITH LIQUID ASSETS TO SHORT-TERM LIABILITIES SHOCK

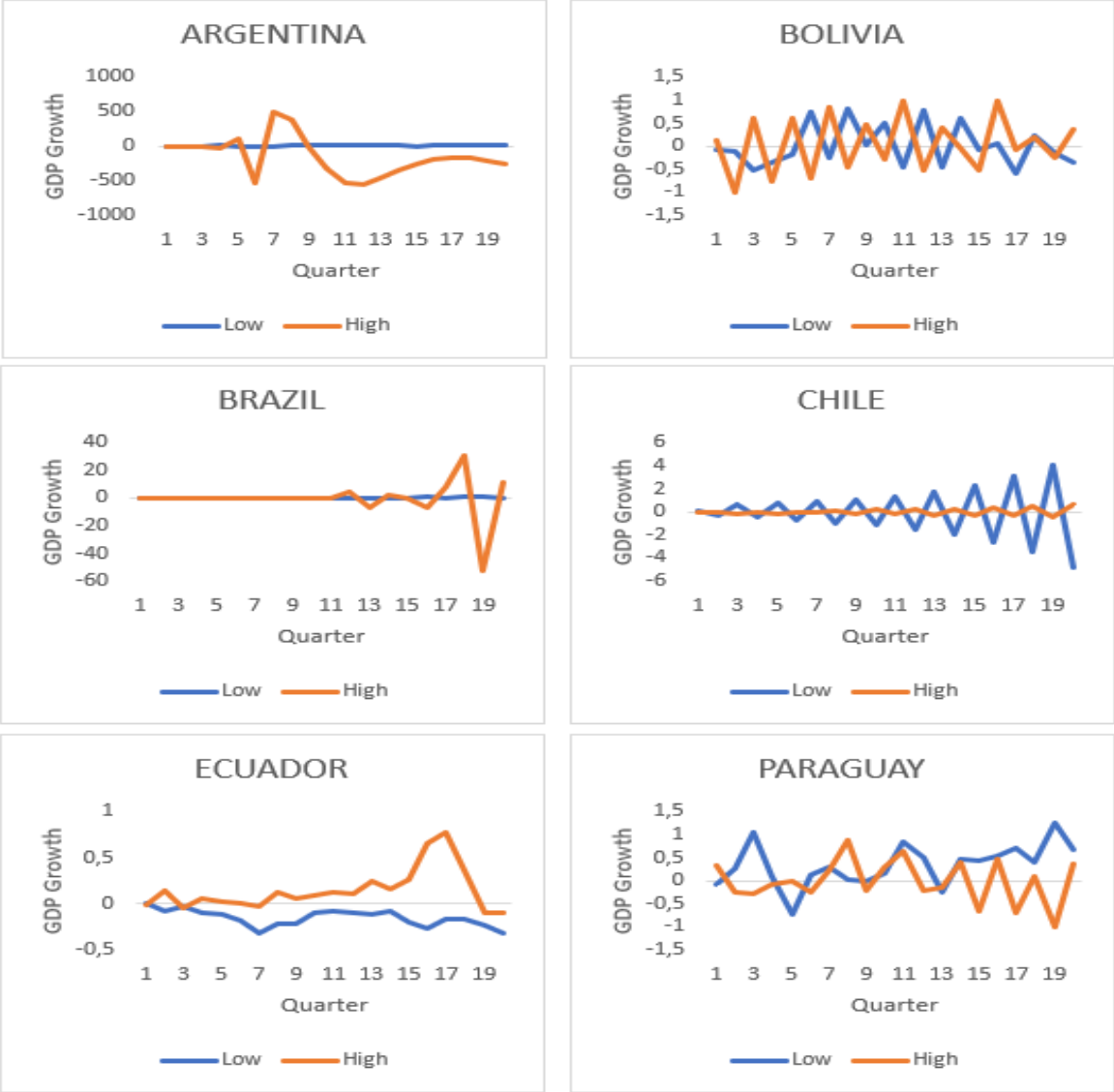
This section analyzes how liquidity assets over short-term liabilities impacts on GDP growth, inflation, nominal interest rate, nominal exchange rate in the face of high and low inflation regimes. The following graphs describes the impulse-response functions of these impacts of the main economic and financial variables, considering inflation and GDP regimes of the main South American countries.

Impulse responses function of GDP growth

The graphs 5.1 and 5.2 describe the impulses responses function of GDP growth with respect to Liquid Assets to Short-Term Liabilities Shock of South American countries, considering of high and low inflation regime. In the case of Argentina, we can observe that in the face of a liquidity shock, GDP is not affected when there are low inflation levels, due to the maintenance of the necessary liquid assets to cover short-term debts. However, when inflation is high, GDP falls starting from the fourth quarter, then grows to a lesser extent and is more volatile on the long run. In the cases of Bolivia and Chile, we can see that the response of GDP to a liquidity shock is volatile in both regimes. GDP increases and decreases from one period to another while increasing or decreasing liquidity. In the case of Brazil, we observe that the shock has no impact on GDP in the short and medium terms in both inflation regimes, but in the long-term, GDP is affected by the variation of liquidity in periods of deflation. A liquidity injection into a dollarized country as Ecuador is not enough to reactivate the economy during a low inflation regime, since its recovery is slow. In Bolivia and Paraguay, the behaviour of GDP is volatile in the face of a liquidity shock. Uruguay, on the other hand, GDP tends to decrease in the short-term and to increase on the long-run, due to liquidity variations, this happens on both inflation regimes.

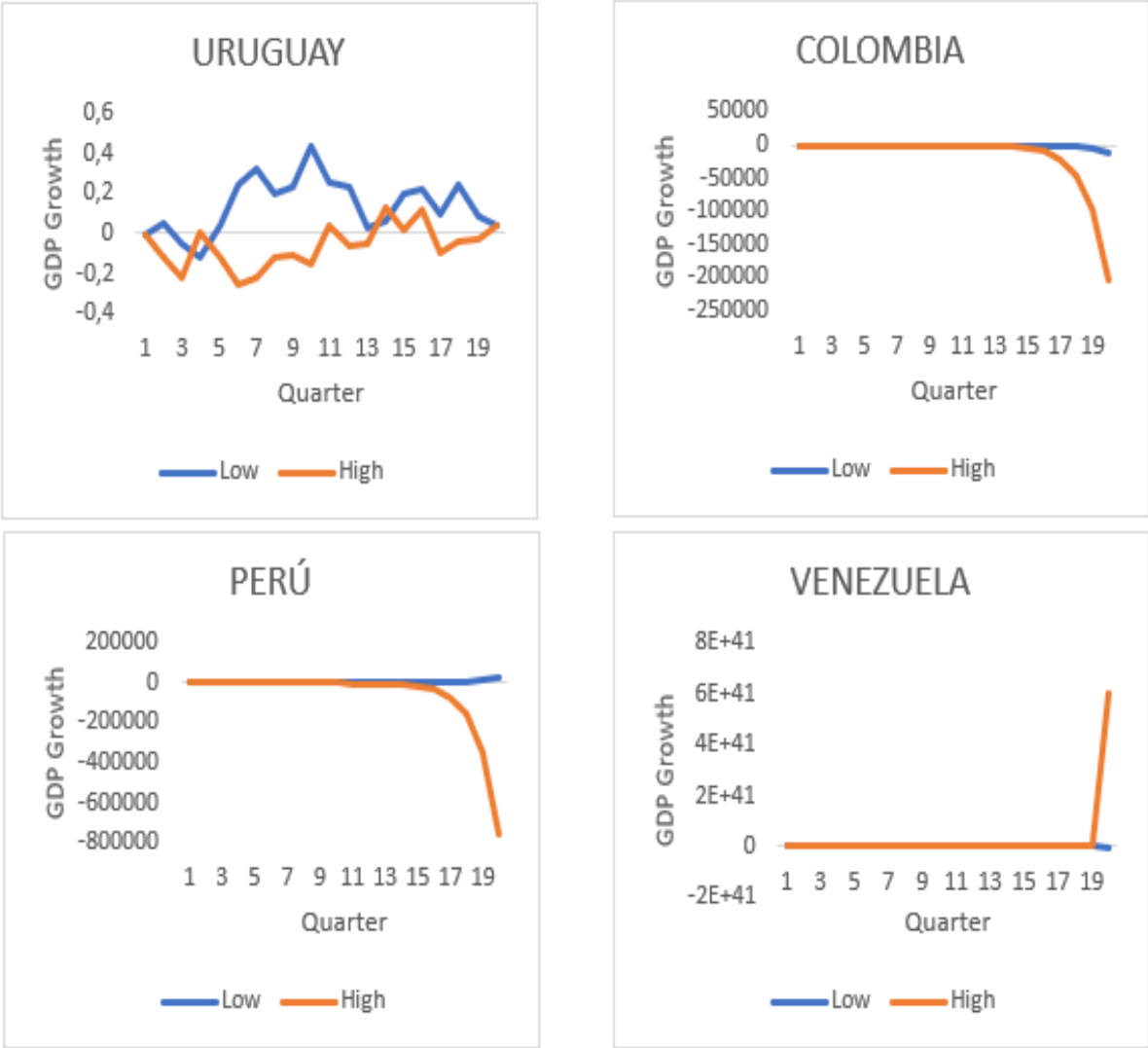
We can see that the effect of a positive liquidity shock on GDP growth in a context where different inflation scenarios are set has different effects between the countries taken into account, both positive and negative. It depends on the interactions of the different variables that are included in the model. These results reflect the dynamics of GDP growth, identified by Bernanke and Gertler (1989), Baumeister et al. (2008) and Caggiano et al. (2018).

Figure 5.1. Inflation Regime - Liquid Assets to Short-Term Liabilities Shock: Impulse responses function of GDP growth (Part 1)



Source: Authors' calculations

Figure 5.2. Inflation Regime - Liquid Assets to Short-Term Liabilities Shock: Impulse responses function of GDP growth (Part 2)



Source: Authors' calculations

Impulse responses function of inflation

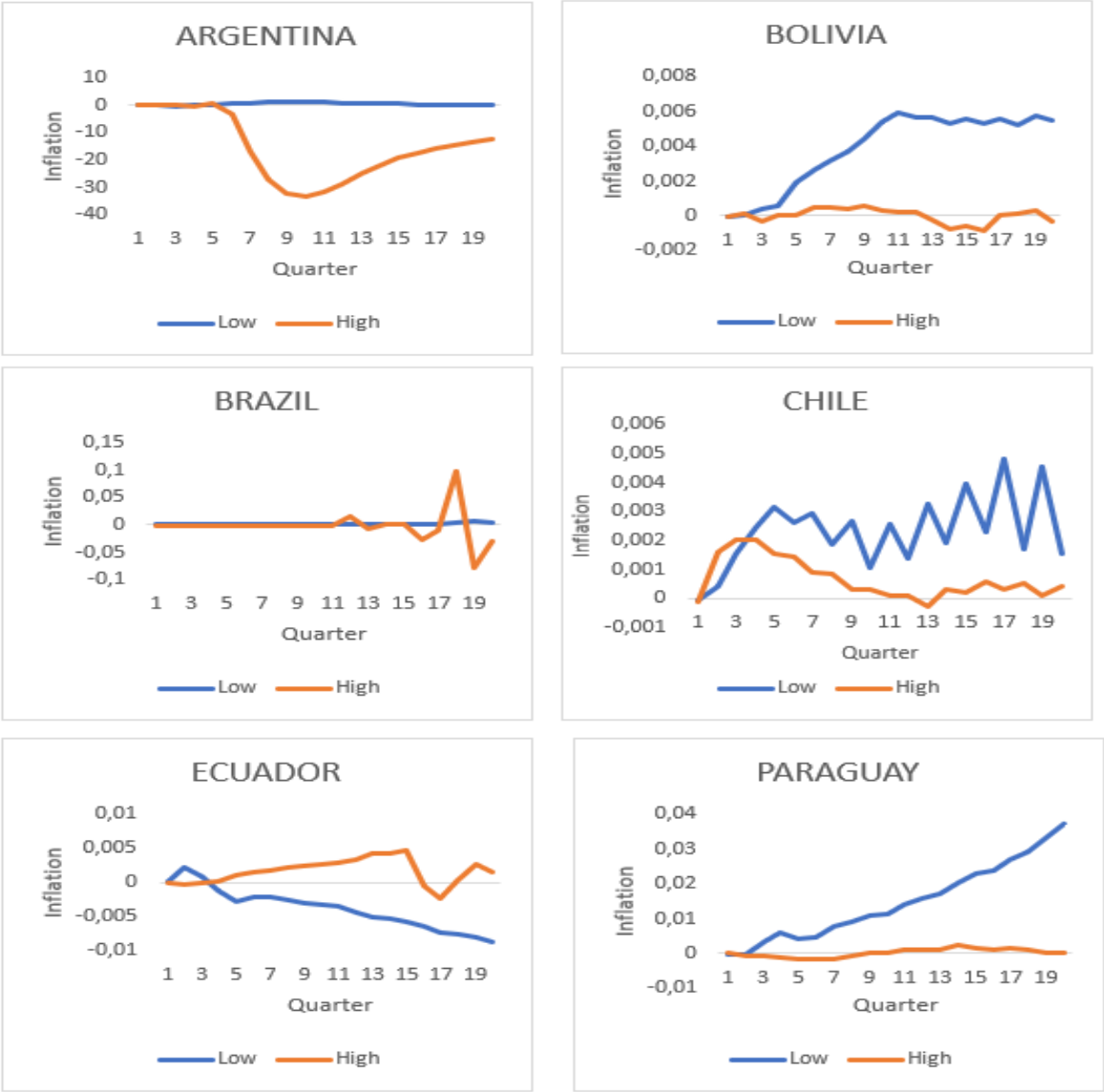
The graphs 5.3 and 5.4 describe the impulses responses function of inflation with respect of Liquid Assets to Short-Term Liabilities Shock of South American countries, considering high and low inflation regime. A liquidity shock in the TVAR model with inflation regime in Latin American countries shows a similar behaviour of inflation in Bolivia, Chile, Paraguay and Uruguay. There is an inflationary effect that is greater when the shock occurs in the low regime compared to the high regime. This result can be explained because an increase in liquidity when there is low inflation produces a greater decrease in interest rates, which, in turn, increases aggregate demand and leads to an increase in inflation. This mechanism is commonly used by monetary authorities to keep inflation levels under control.

On the other hand, in the case of Argentina, we observe that inflation does not vary over time in the low regime, however, in the high regime a deflationary effect is observed in the medium and long terms. In Brazil, there is no response of inflation since it remains around 0 until the seventeenth quarter in

both regimes. These results can be explained by the existence of liquidity traps, where an expansionary monetary policy does not produce the expected effect, therefore, aggregate demand is not stimulated, and the money product of the shock remains in circulation.

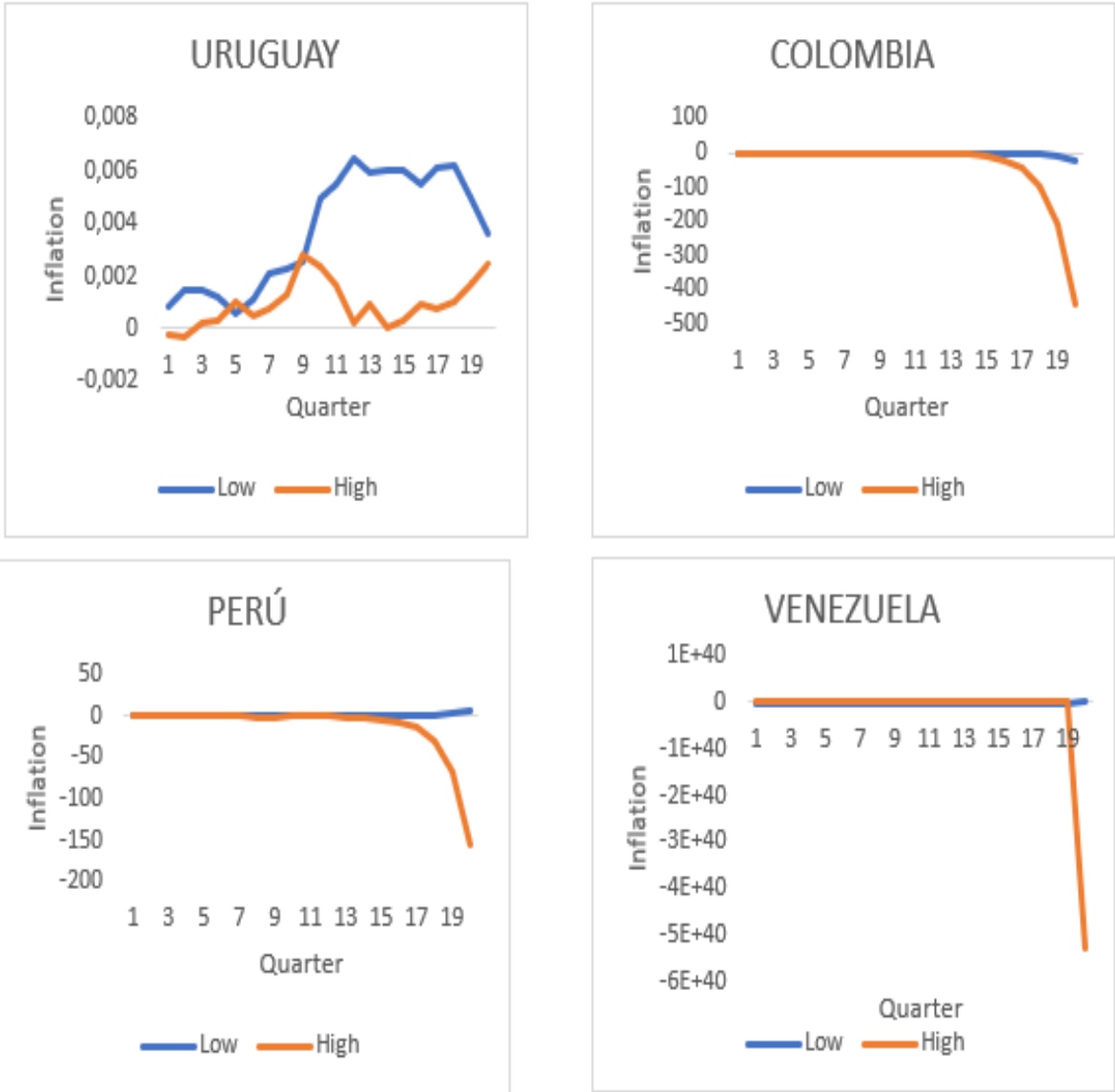
Finally, in Ecuador there is a different effect on each regime. In the high regime, there are inflationary pressures, while in the low regime, inflation decreases over the estimated time. The results obtained follow the dynamics presented by Grilli and Roubini (1996), Saki Bigio and Jorge Salas (2006), Baumeister et al. (2008), Caggiano et al. (2018).

Figure 5.3. Inflation Regime - Liquid Assets to Short-Term Liabilities Shock: Impulse Responses Function of Inflation (Part 1)



Source: Authors' calculations

Figure 5.4. Inflation Regime - Liquid Assets to Short-Term Liabilities Shock: Impulse Responses Function of Inflation (Part 2)



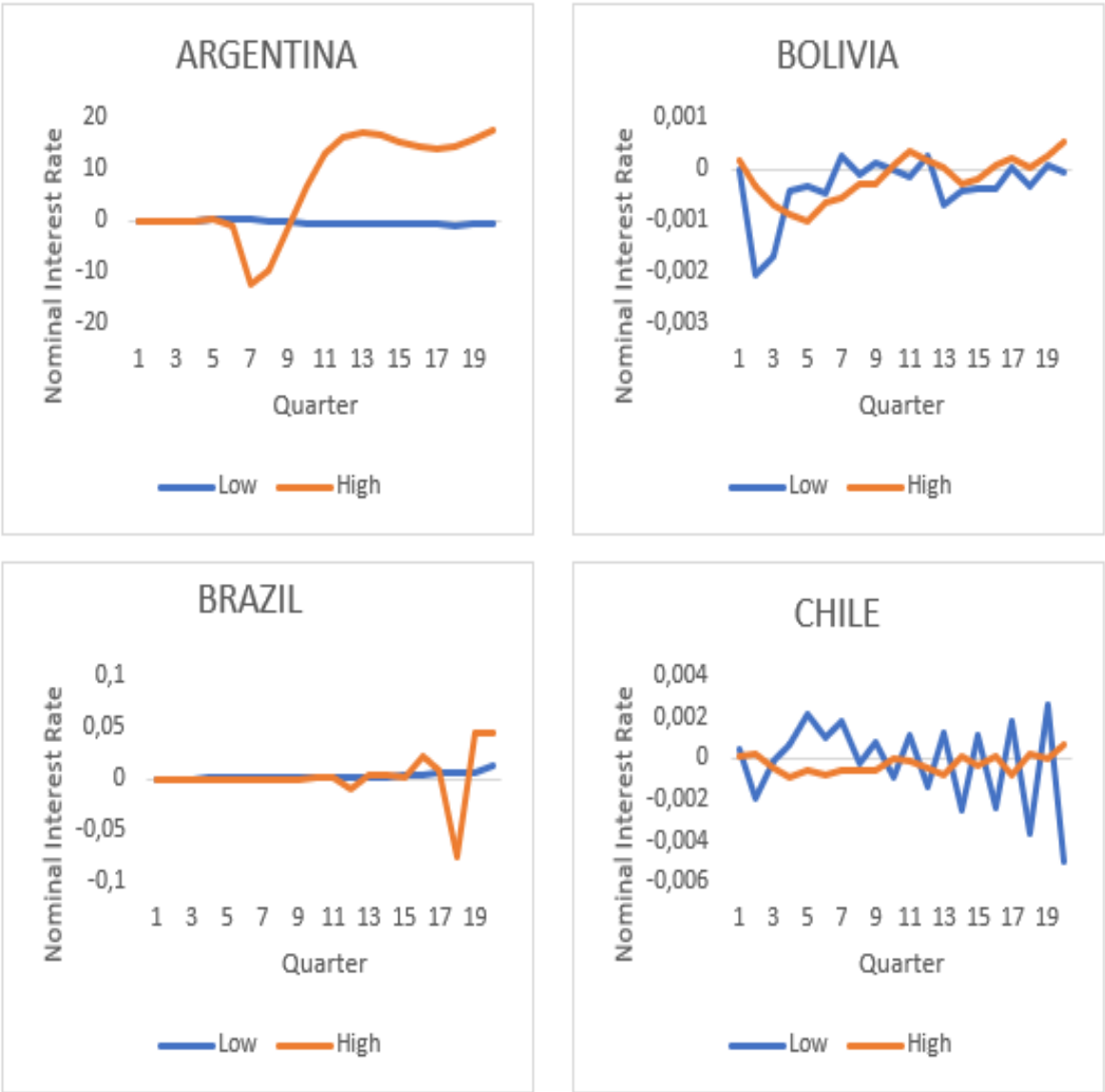
Source: Authors' calculations

Impulse responses function of nominal interest rate

The graphs 5.5 and 5.6 describe the impulse responses function of nominal interest rate with respect of Liquid Assets to Short-Term Liabilities Shock of South American countries, considering of high and low inflation regime. The impulse-response functions of the nominal interest rate in the face of a liquidity shock by the TVAR model, considering the high and low inflation regimes show that, in Argentina, the nominal interest rate does not change over time by the shock in a low inflation regime, but in a high regime, it decreases in quarter seven and increases greatly in subsequent quarters. In the case of Bolivia, the nominal interest rate decreases in the short-term in both regimes after a liquidity shock; this effect tends to be diluted in subsequent quarters where the interest rate is positioned at values close to 0. In Brazil, the shock does not have effects on the nominal interest rate in the short and medium terms, however, there are high variations in the long-term in only on a high inflation regime. Chile's nominal interest rate is affected differently depending on the regime in which inflation is found at the time of the shock, with a decreasing effect in the high regime, and great instability in the low regime. In Ecuador, the liquidity shock causes a similar effect in the short-term in both regimes, where inflation decreases with a greater scope in the low regime. In the medium and long terms, the interest rate tends to increase in the low regime, while it decreases in the high regime. In the case of Paraguay, the shock causes the interest rate to decrease in the low inflation regime, while in the high regime it remains unchangeable. Finally, in Uruguay, the effect of the shock on the interest rate is marked by movements in both regimes, however, the effect is greater in magnitude when the shock occurs in the low regime.

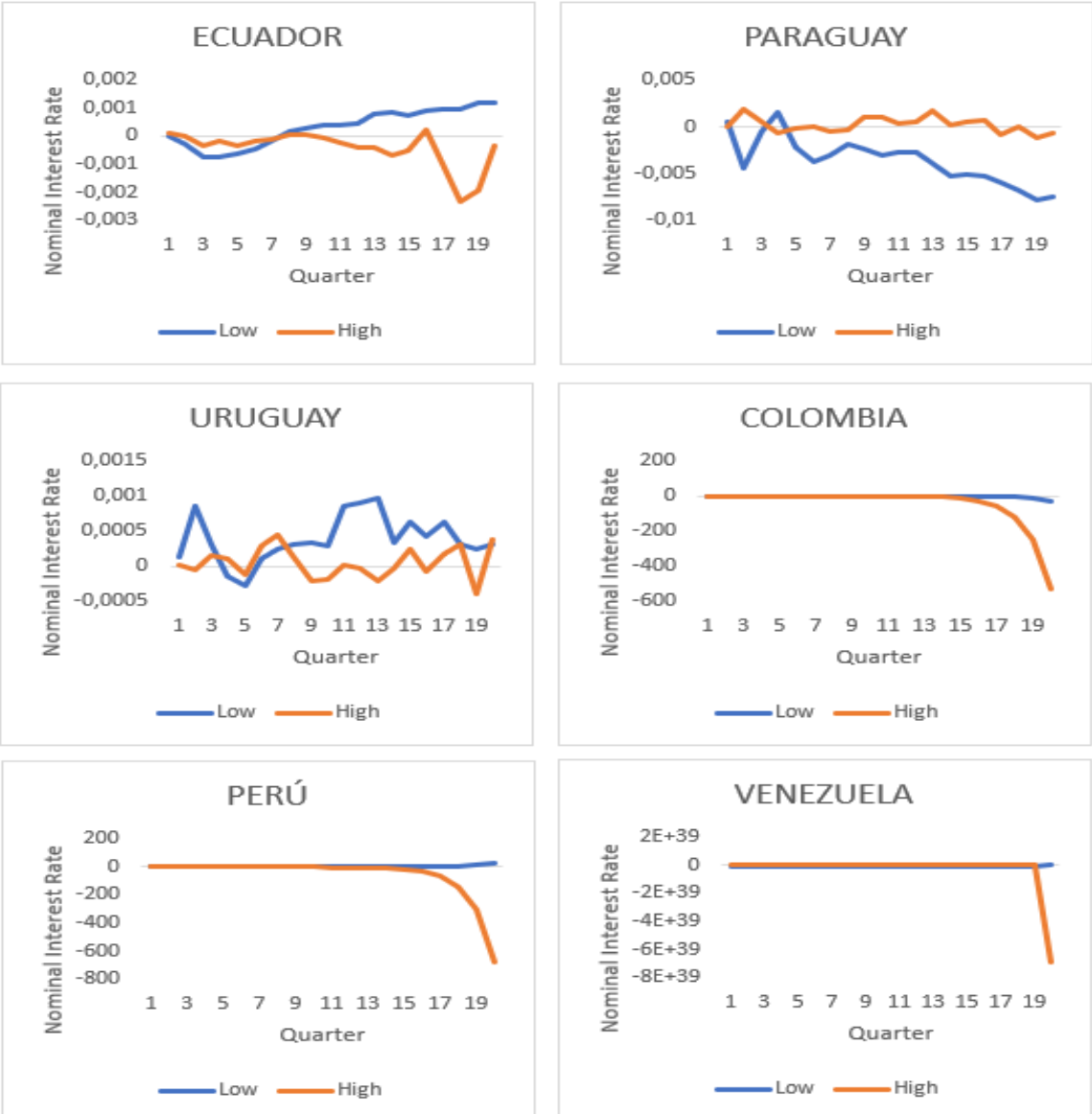
The response of the nominal interest rate to a positive liquidity shock considering inflation regimes depends on the state of the economy at the time of the shock. A decrease of the nominal interest rate can be attributed to the liquidity effects that indicate the existence of an inverse relationship between interest rates and the monetary policy, Friedman (1968). The results obtained follow the dynamics of Lucas (1990), Grilli and Roubini (1992), Caggiano et al. (2018).

Figure 5.5. Inflation Regime - Liquid Assets to Short-Term Liabilities Shock: Impulse Responses Function of Nominal Interest Rate (Part 1)



Source: Authors' calculations

Figure 5.6. Inflation Regime - Liquid Assets to Short-Term Liabilities Shock: Impulse Responses Function of Nominal Interest Rate (Part 2)

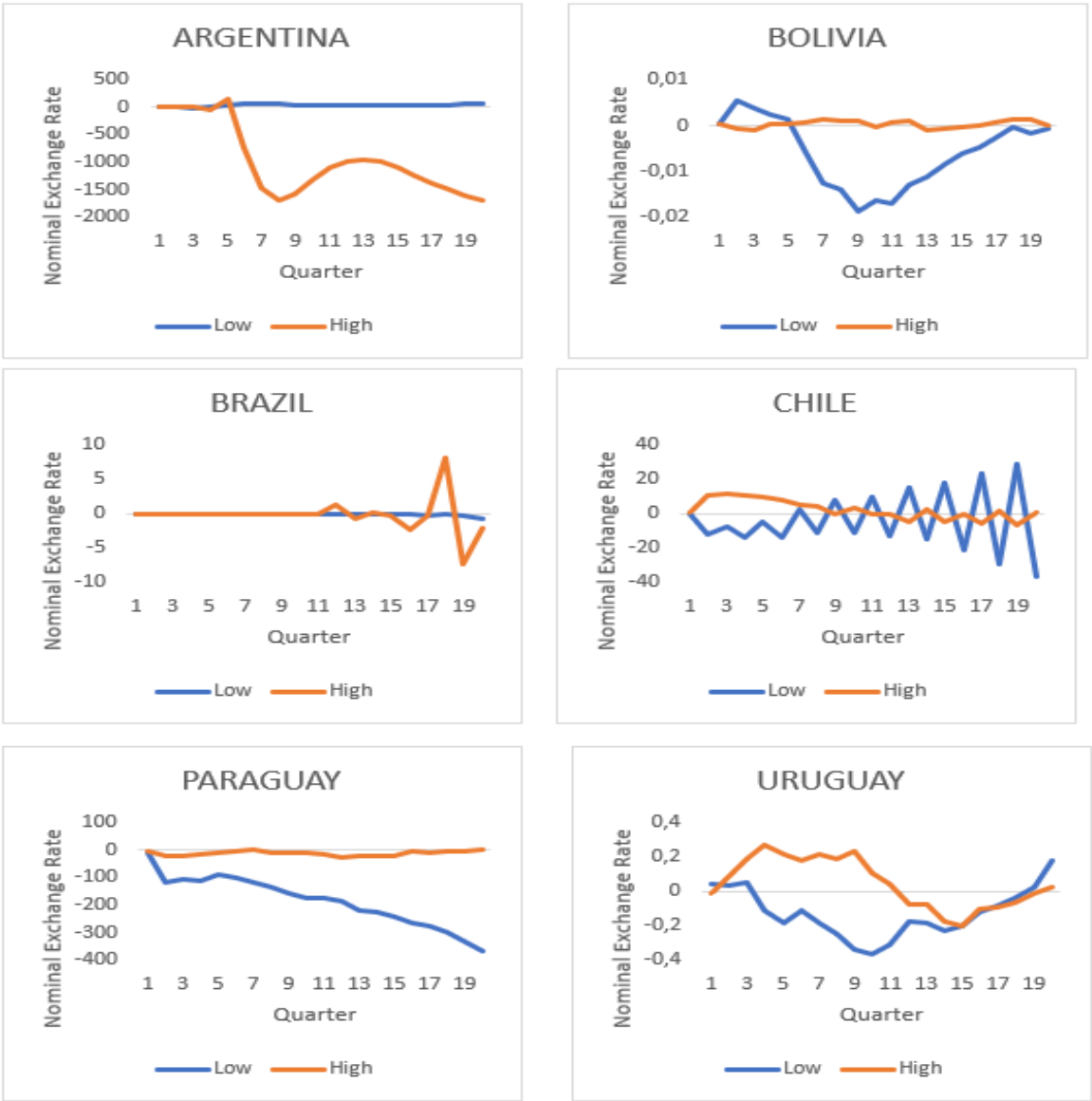


Source: Authors' calculations

Impulse responses function of Nominal Exchange rate

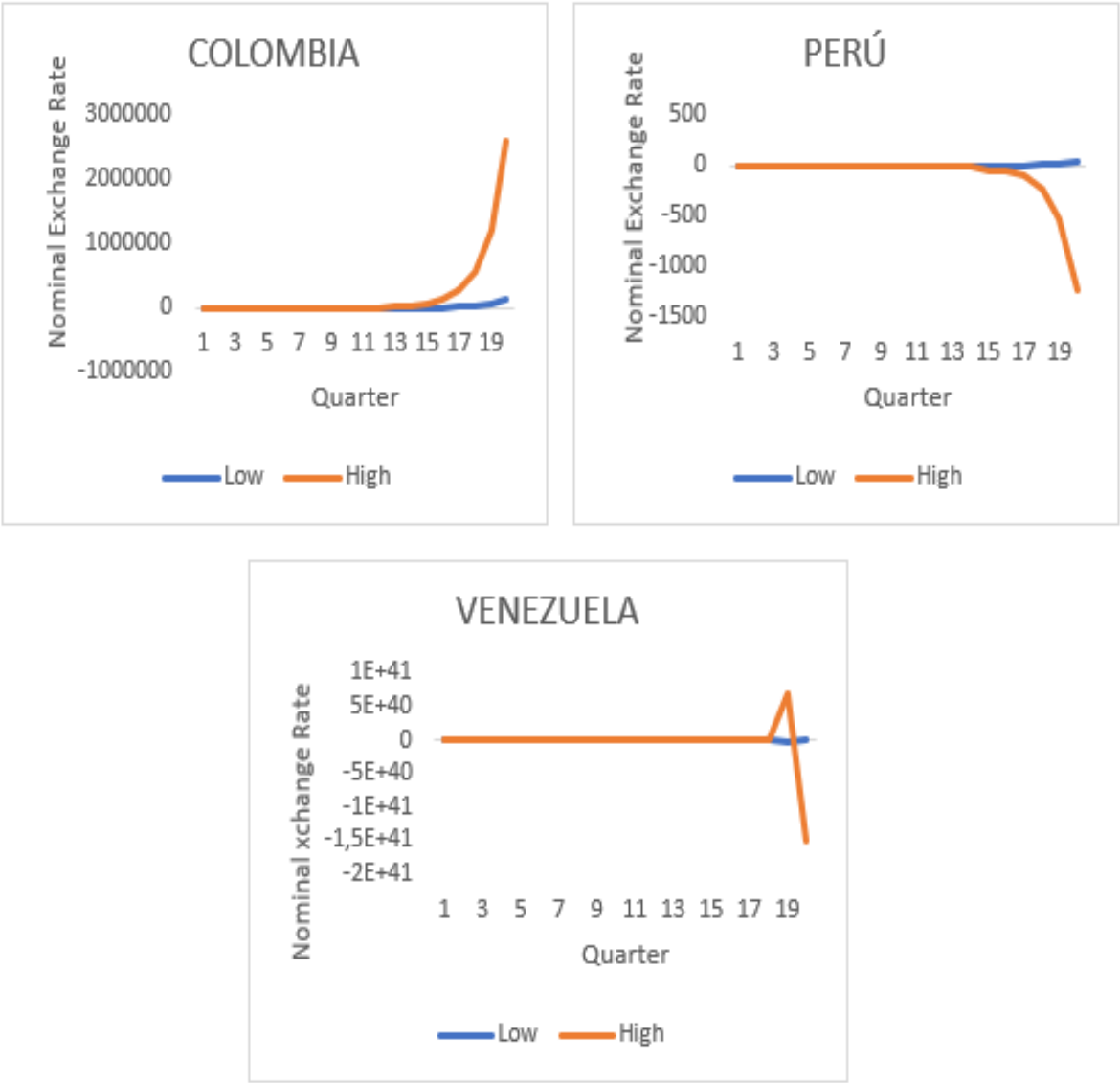
The graphs 5.7 and 5.8 describe the impulse responses function of nominal exchange rate with respect to Liquid Assets to Short-Term Liabilities Shock of South American countries, considering high and low inflation regime. The impulse-response functions of the nominal exchange rate in the face of a positive liquidity shock for Latin American countries in a TVAR model with inflation regimes notes that the nominal exchange rate in Argentina is not affected by the shock in the low inflation regime. While, in the high inflation regime, the exchange rate depreciates as of the third quarter. On the contrary, in Bolivia, the exchange rate does not have great variations in the high regime, but in the low regime, a large depreciation occurs and tends to recover in the long-term. Likewise, for Brazil, the exchange rate is not affected by the shock in the low inflation regime, while in the high regime it is not affected until the twelfth quarter, with greater variation for subsequent quarters. In Chile, the exchange rate has opposite responses after the regime-dependent shock. In the low regime the exchange rate depreciates after the shock while in the high regime it appreciates. In addition, it is observed that there is greater instability in the nominal exchange rate in the low regime as time passes. In the case of Paraguay, the shock does not produce any effect in the high regime, but the nominal exchange rate has a strong depreciation over time in the low regime. Finally, in Uruguay the exchange rate increases in the high regime and decreases in the low regime, these effects continue until the ninth quarter after the shock. Subsequently, the exchange rate decreases in the high regime and increases in the low regime. The results obtained are in accordance with what was stated by Grilli and Roubini (1996) and Bigio and Salas (2008). They explain that liquidity shocks can affect the exchange rate through different transmission channels such as interest rates, or the level of inflation.

Figure 5.7. Inflation Regime - Liquid Assets to Short-Term Liabilities Shock: Impulse responses function of Nominal Exchange Rate (Part 1)



Source: Authors' calculations

Figure 5.8. Inflation Regime - Liquid Assets to Short-Term Liabilities Shock: Impulse re- sponses function of Nominal Exchange Rate (Part 2)



Source: Authors' calculations

5.5.2. GDP REGIME WITH LIQUID ASSETS TO SHORT-TERM LIABILITIES SHOCK

Impulse responses function of GDP growth

The graphs 5.9 and 5.10 describe the impulse responses function of GDP growth with respect of Liquid Assets to Short-Term Liabilities Shock of South American countries, considering of high and low GDP growth regime. The impulse response functions of GDP growth show a positive liquidity shock in majority South American countries. Argentina and Uruguay reflect a similar behaviour, where the shock causes an increase in GDP in the expansion regime, while in the contraction regime it causes the deepening of the economic crisis, the effect being greater in magnitude in the contraction regime. The result observed in the contraction regime can be explained by the fact that the shock produced an excess of liquidity with negative effects on the economy, just as it happened in the international financial crisis, where a financial bubble originated that had a recessive effect ((Jauregui, 2018)).

On the other hand, a similar behaviour is observed between the responses of the countries Brazil and Chile, determined by a null effect of the shock in the short and medium term in both regimes, while, in the long term, the response of GDP maintains a behaviour volatile marked by increases and decreases for the two countries. This result reflects the existence of liquidity traps in the Brazilian and Chilean economies, since it is observed that an expansionary monetary policy measure loses its ability to stimulate economic activity. As for Paraguay and Bolivia, the response to GDP growth reveals instability determined by increases and decreases similar in magnitude and duration in both regimes. This responds to the high volatility in GDP growth that the two countries have throughout the study period.

Finally, the response of Ecuador's GDP has a different behaviour from that of the different countries, since a positive liquidity shock induces economic growth both in the expansion regime and in the contraction regime. However, the effect is greater when the shock occurs during the economic expansion. This means that an increase in liquidity will benefit the Ecuadorian economy regardless of the state in which it is located without generating excess liquidity with negative consequences. This result responds to the fact that when there is an increase in liquidity, the financial system has a greater capacity to offer credits to the different economic sectors, thus promoting production, which leads to an increase in GDP growth.

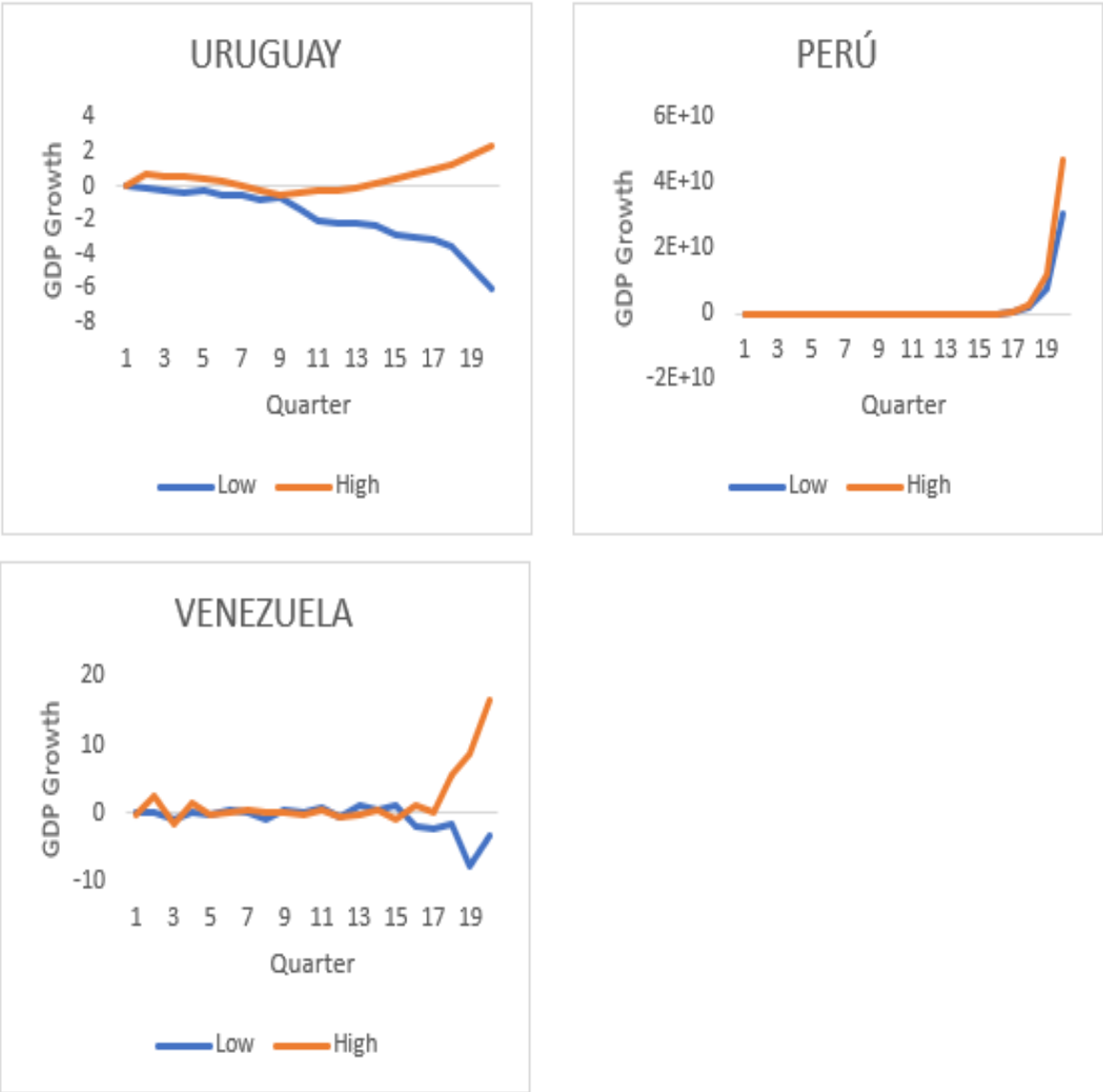
As can be seen, the effect of a positive liquidity shock on GDP growth has different dynamics in the different study countries with both positive and negative effects. This result depends on the interactions of the different variables included in the model, as well as on the history presented between liquidity and the growth of individual GDP in each country. These results follow the dynamics of the results presented by Bernanke and Gertler (1989), Baumeister et al. (2008) and Caggiano et al. (2018).

Figure 5.9. GDP growth Regime – Liquidity assets to short term liabilities Shock: Impulse responses function of GDP growth (Part 1)



Source: Authors' calculations

Figure 5.10. GDP growth Regime – Liquidity assets to short term liabilities Shock: Impulse responses function of GDP growth (Part 2)



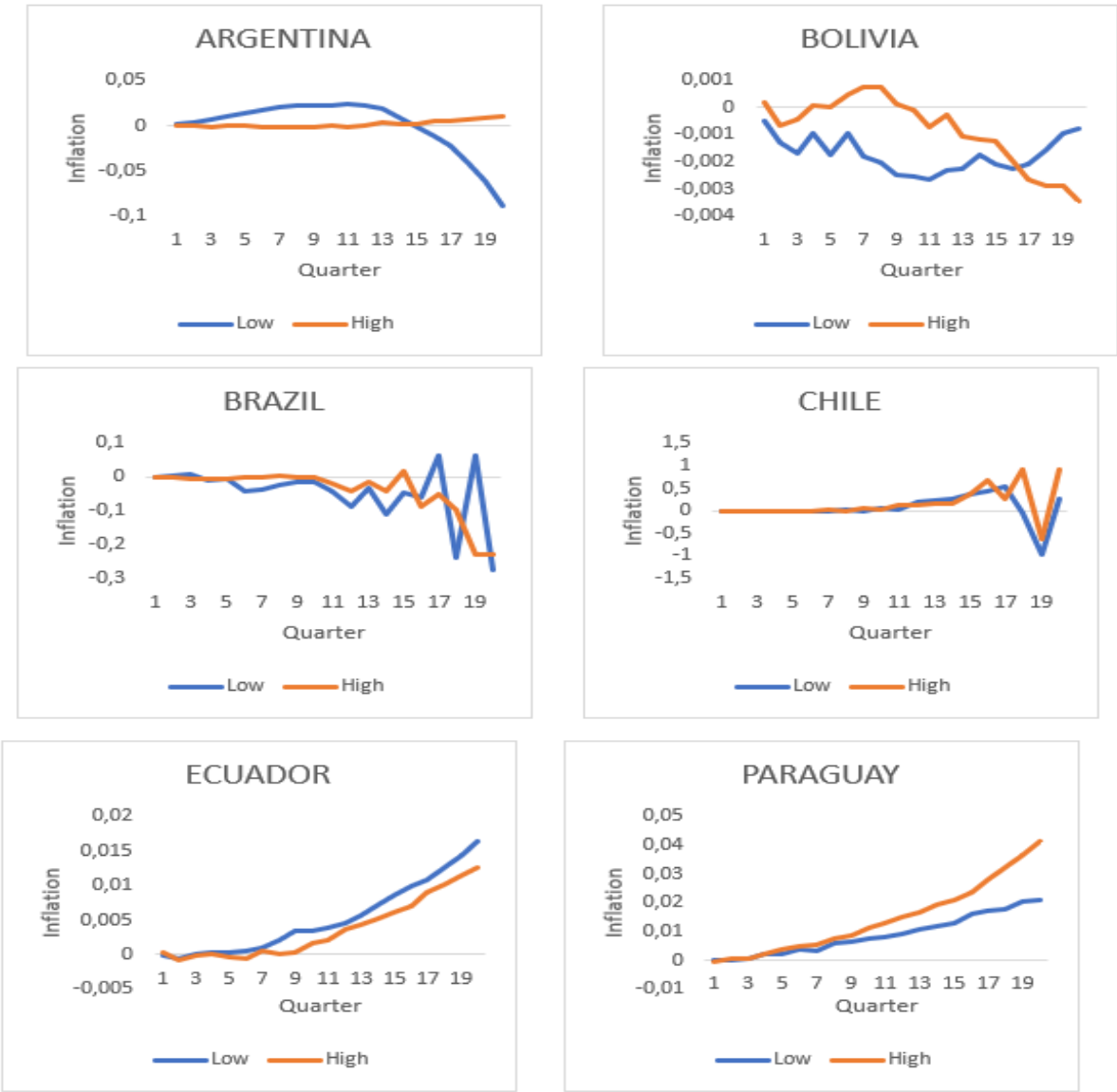
Source: Authors' calculations

Impulse responses function of Inflation

The graphs 5.11 and 5.12 describe the impulse responses function of inflation with respect of Liquid Assets to Short-Term Liabilities Shock of South American countries, considering of high and low GDP growth regime. The previous graph shows the impulse response functions of inflation in the event of a positive shock in Liquid Assets to Short Term Liabilities of Latin American countries for the TVAR model with GDP regime. In the graph it is possible to differentiate between two groups of countries with similar results. The first group corresponds to Argentina, Bolivia and Brazil, in these countries the effect of a positive liquidity shock is mainly characterized by a decrease in inflation. In Argentina, it is observed that in the short term the effect is insignificant, however, in the long term, deflationary pressures are observed in the contraction regime. For Bolivia, the deflationary effect exists in the short term, which has a greater magnitude in the economic contraction regime. While, in Brazil, the shock does not have significant effects in the short and medium term in both regimes. However, as of the fifteenth quarter, the decrease in inflation is also observed for the two regimes. This result may be due to the existence of what are known as liquidity traps, in which conventional monetary policies do not have the power to alter the level of prices of goods, and, therefore, inflation, causing liquidity to remain low. possession of economic agents.

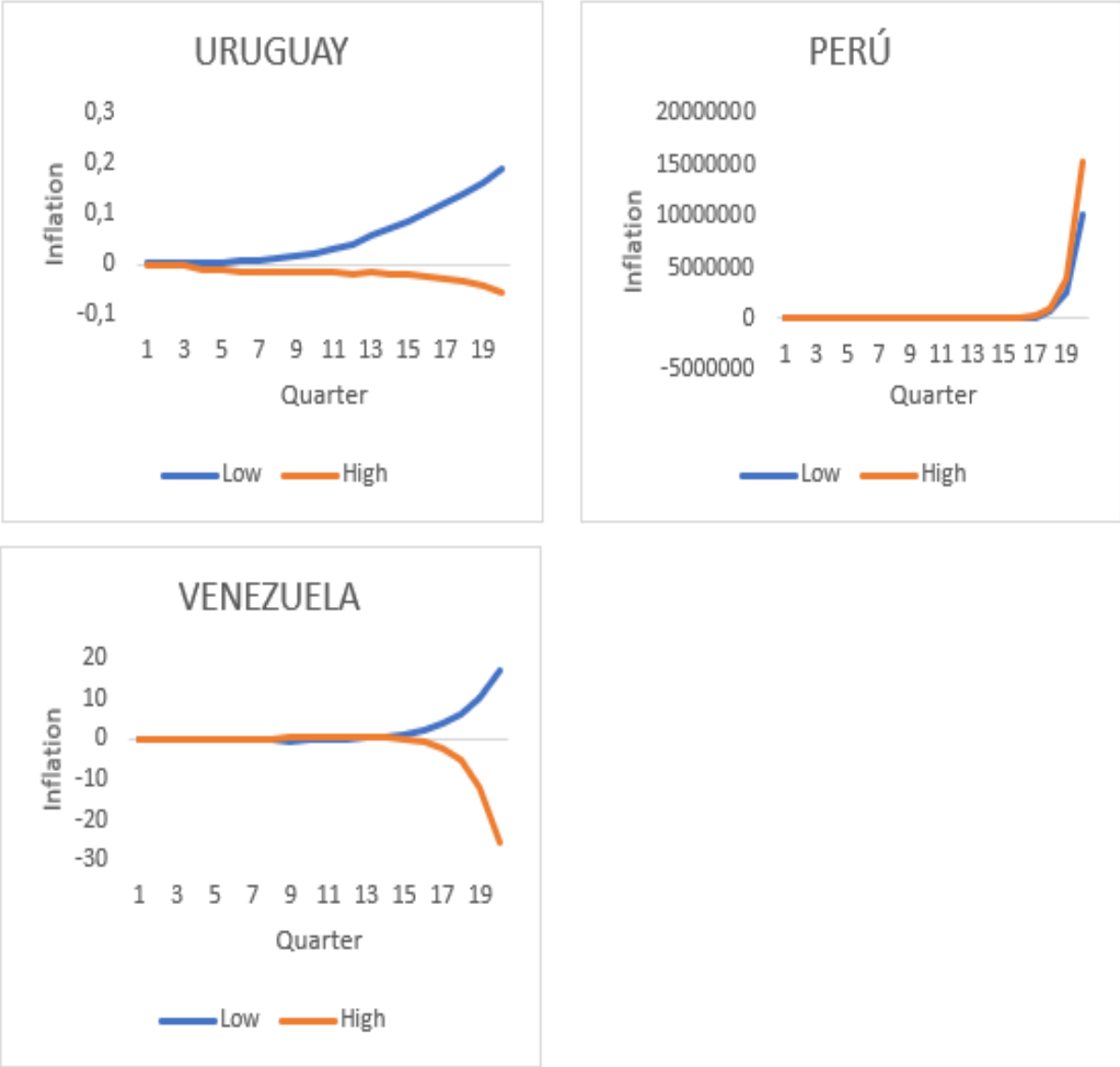
On the other hand, the second group corresponds to Chile, Ecuador, Paraguay and Uruguay. This group is distinguished by the existence of inflationary pressures in the face of a liquidity shock. Within this group of countries there are two subgroups: I) Chile and Paraguay where the inflationary effect is greater in magnitude in the expansion regime. II) Ecuador and Uruguay in which the effect of the inflation shock is greater in the contractionary regime. This result responds to the fact that an increase in liquidity tends to lower interest rates, which generates an increase in aggregate demand, increasing private spending, which ends up affecting the price level, producing an increase in inflation. The results obtained follow the dynamics of the results presented by Grilli and Roubini (1996), Bigio and Salas (2008), Baumeister et al. (2008), Caggiano et al. (2018).

Figure 5.11. GDP growth Regime – Liquidity assets to short term liabilities Shock: Impulse responses function of Inflation (Part 1)



Source: Authors' calculations

Figure 5.12. GDP growth Regime – Liquidity assets to short term liabilities Shock: Impulse responses function of Inflation (Part 2)



Source: Authors' calculations

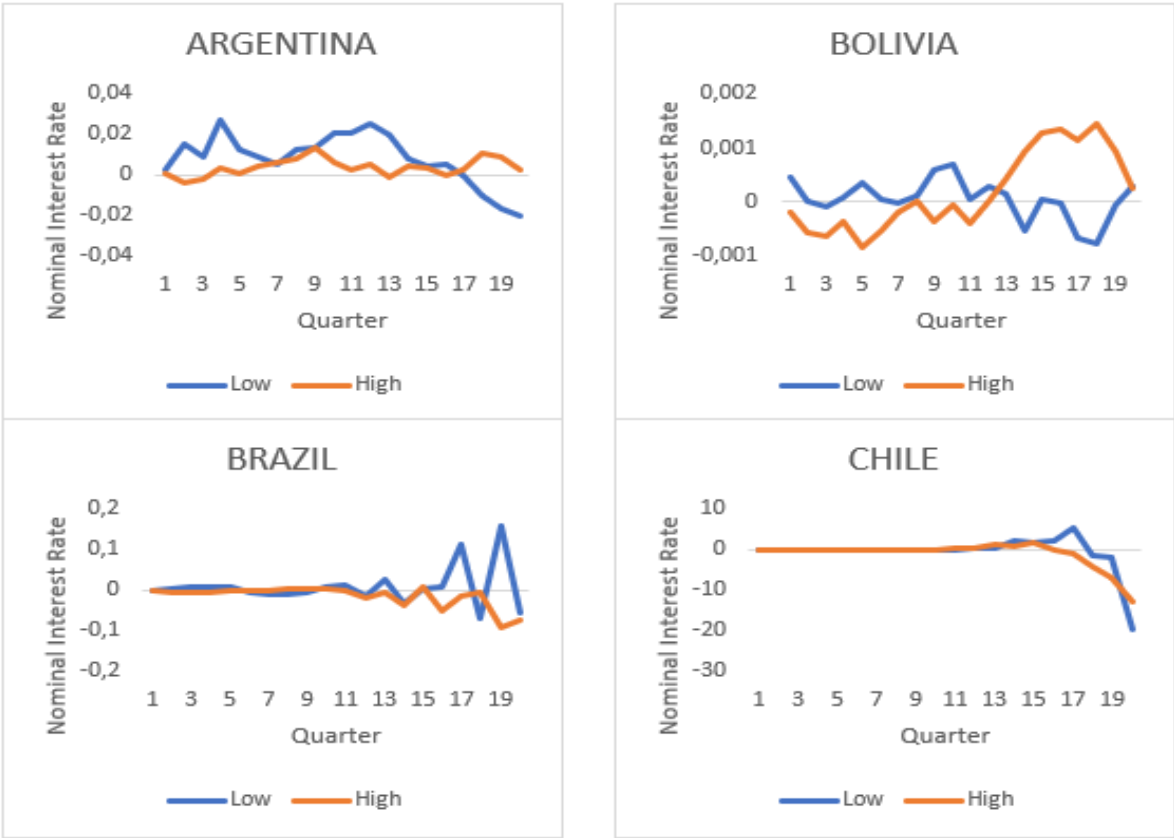
Impulse responses function of Nominal Interest rate

The graphs 5.13 and 5.14 describe the impulse responses function of nominal interest rate with respect of Liquid Assets to Short-Term Liabilities Shock of South American countries, considering of high and low GDP growth regime. The responses of the nominal interest rate to a positive liquidity shock corresponding to the majority South American countries. Argentina's nominal interest rate increases in both regimes; however, it has a greater increase when the shock occurs in a contractionary regime. Bolivia presents a different behaviour in both regimes. In the low regime, the nominal interest rate increases at the moment of the shock. Then it continues to rise and fall until it decreases in the long term, while in the high regime the interest rate is negatively affected at the moment of the shock, and tends to grow in the long term.

In the case of Brazil and Chile, a positive liquidity shock produces a null effect on interest rates in the short and medium term in both regimes, and then, in the long term, decreases in both regimes. In Ecuador the effect of the shock produces a decrease in the interest rate in both regimes in the short term, however, in the expansive regime the effect tends to be maintained, while in the contractive regime the growth of the interest rate is observed. In the short term, in the case of Paraguay, the effect on the interest rate is close to 0 in the short and medium term in both regimes. In the long term an opposite effect is observed where the interest rate increases in the expansionary regime, and decreases in the contractual regime.

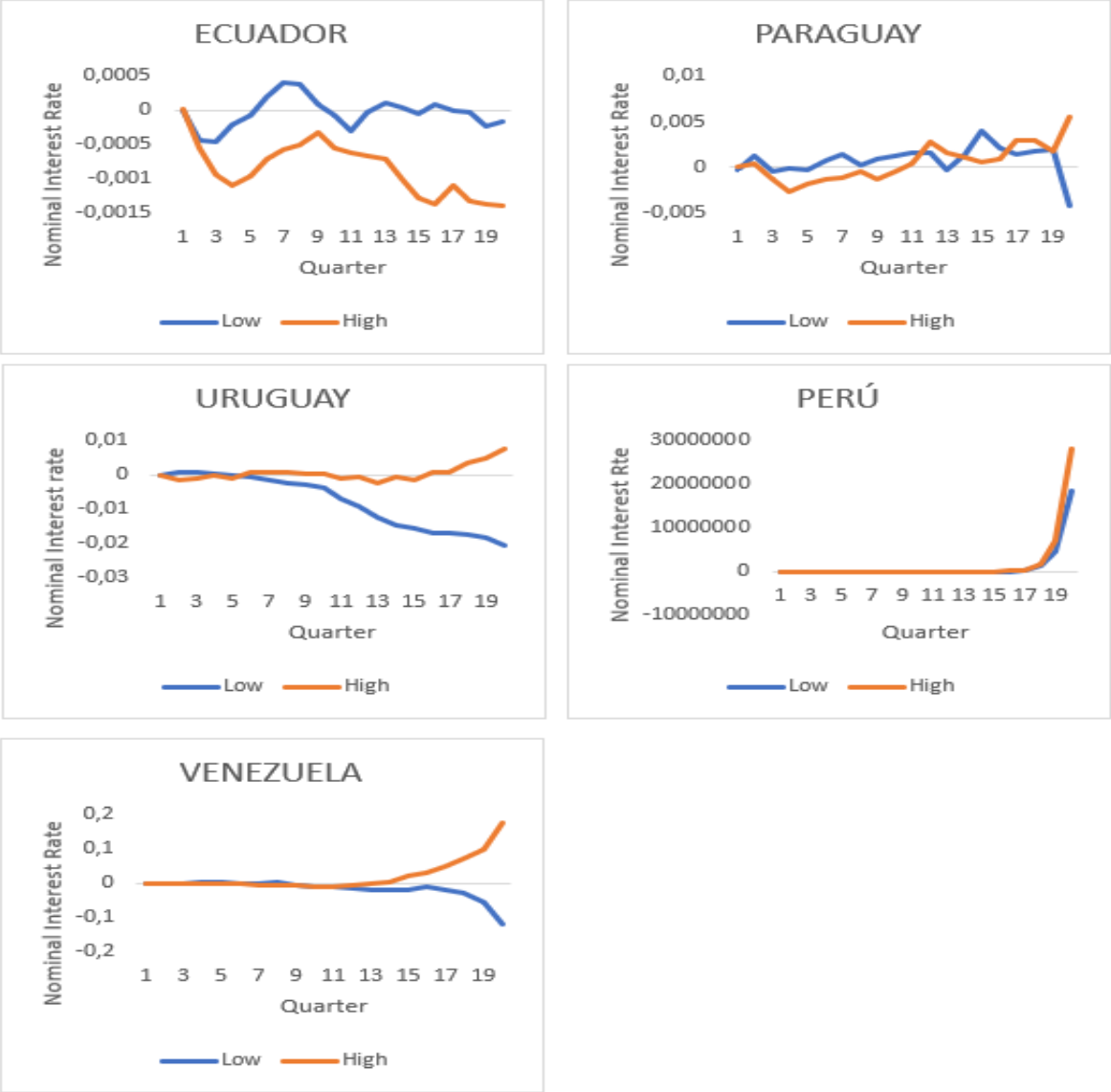
As can be seen in the graph, the response of the nominal interest rate to a positive liquidity shock depends on the state of the economy at the time of the shock, which is why it is verified that there are asymmetric relationships between the different variables macroeconomics of Latin American countries. The decrease in interest rates responds to the existence of "Liquidity Effects" proposed by Friedman (1968) who maintains that there is an inverse relationship between interest rates and monetary policy. Likewise, these results follow the dynamics of the results presented by Grilli and Roubini (1992) Lucas (1990), Grilli and Roubini (1992), Baumeister et al. (2008) and Caggiano et al. (2018).

Figure 5.13. GDP growth Regime – Liquidity assets to short term liabilities Shock: Impulse Response Function of Interest Rate (Part 1)



Source: Authors' calculations

Figure 5.14. GDP growth Regime – Liquidity assets to short term liabilities Shock:Impulse Responses Function of Interest Rate (Part 2)



Source: Authors' calculations

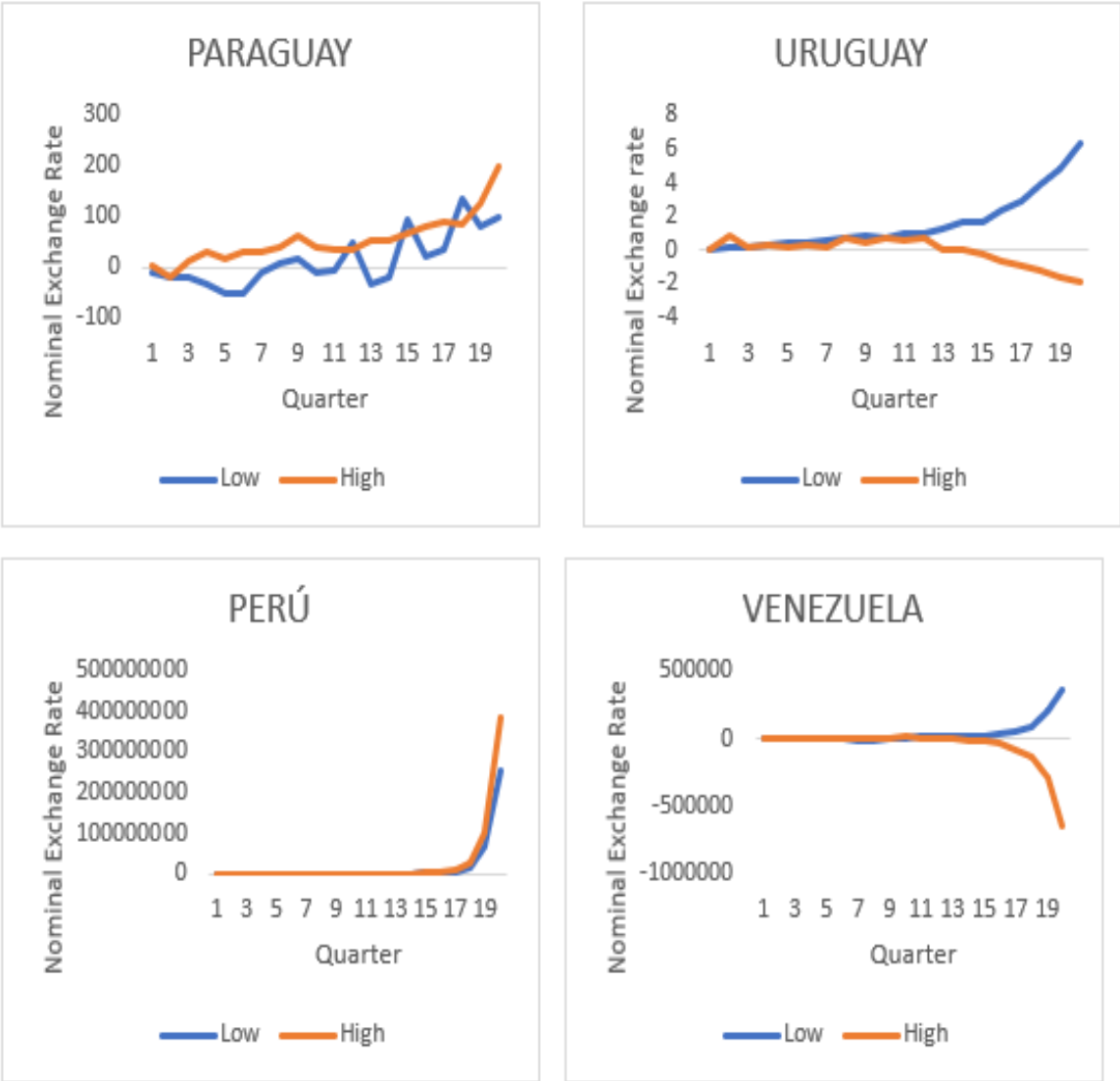
Impulse responses function of Nominal Exchange rate

The graphs 5.15 and 5.16 describe the impulse responses function of nominal exchange rate with respect of Liquid Assets to Short-Term Liabilities Shock of South American countries, considering of high and low GDP growth regime. In Argentina, the exchange rate is not affected over time by the shock when there is high economic growth. On the contrary, when the liquidity shock occurs in a scenario of economic contraction, it causes the exchange rate to rise significantly in the medium and long term. This appreciation of the exchange rate would cause exports to decline, causing economic growth to decline. In Bolivia, an appreciation of the exchange rate can be observed in the face of a liquidity shock in the short term in both regimes, however, in the long term, during the expansion regime a greater appreciation is identified, while in the contractionary regime look at the effect of exchange rate depreciation.

As for Brazil, the effect of the liquidity shock is negligible in the short and medium term in both regimes. On the contrary, in the long term, the exchange rate tends to increase in a regime of low economic growth, and to decrease in the regime of high growth. In the case of Chile, the nominal exchange rate is not affected until the fifteenth quarter in both regimes. From this period on, the exchange rate depreciates in both regimes to a similar magnitude. In Paraguay, a liquidity shock causes an appreciation of the nominal exchange rate in both regimes; this effect grows over time, but with greater magnitude in a regime of high economic growth, in relation to the regime of low growth. Finally, in Uruguay, the exchange rate response is zero until the eleventh quarter in both regimes. As of this quarter, an opposite behaviour of the exchange rate is observed in the different regimes. In the contractive regime, the exchange rate increases, while, in the expansionary regime, the exchange rate decreases.

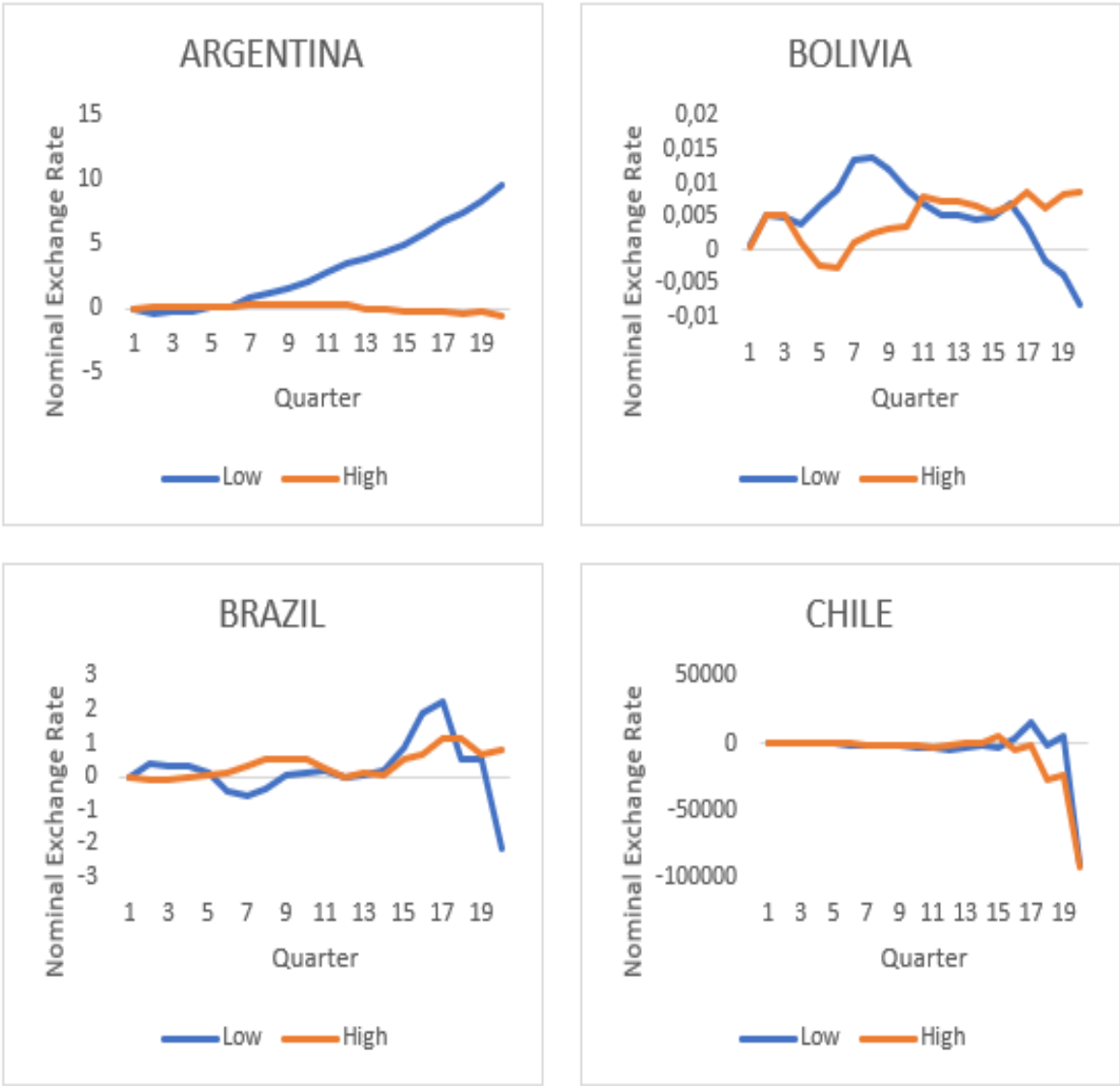
The results obtained are in accordance with what was stated by Grilli and Roubini (1992) and Bigio and Salas (2008). Where they explain that liquidity shocks can affect the exchange rate through different transmission channels such as interest rates, or the level of inflation.

Figure 5.15. GDP growth Regime – Liquidity assets to short term liabilities Shock:Impulse Responses Function of Nominal Exchange Rate (Part 1)



Source: Authors' calculations

Figure 5.16. GDP growth Regime – Liquidity assets to short term liabilities Shock:Impulse Response Function of Nominal Exchange Rate (Part 2)



Source: Authors' calculations

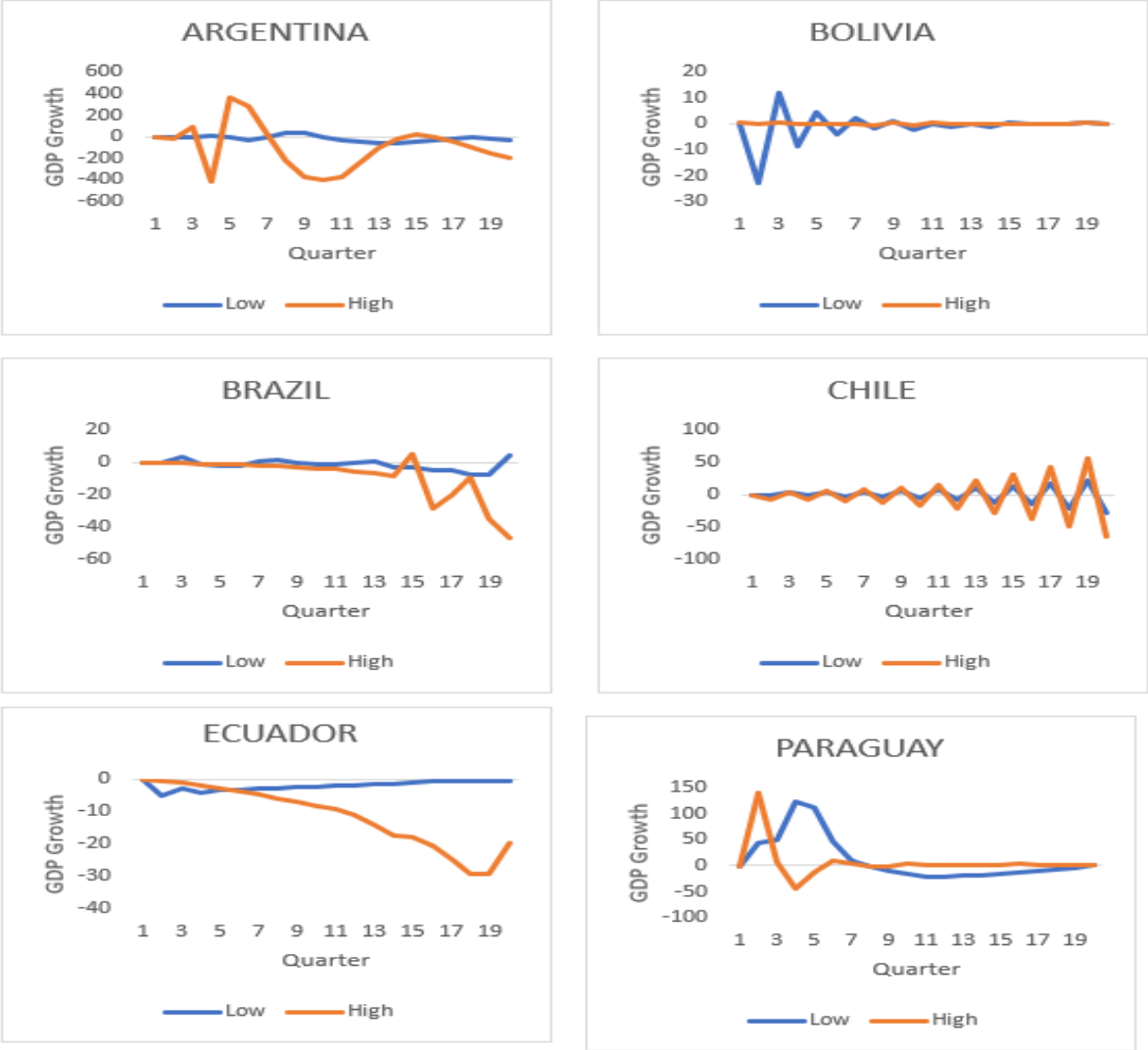
5.5.3. INFLATION REGIME WITH M2/GDP SHOCK

This section analyzes how the M2 over GDP impacts on GDP growth, inflation, nominal interest rate, nominal exchange rate in the face of high and low inflation regimes. The following graphs show the impulse-response functions of these impacts of the main economic and financial variables, considering inflation and GDP regimes of the main South American countries.

Impulse responses function of GDP growth

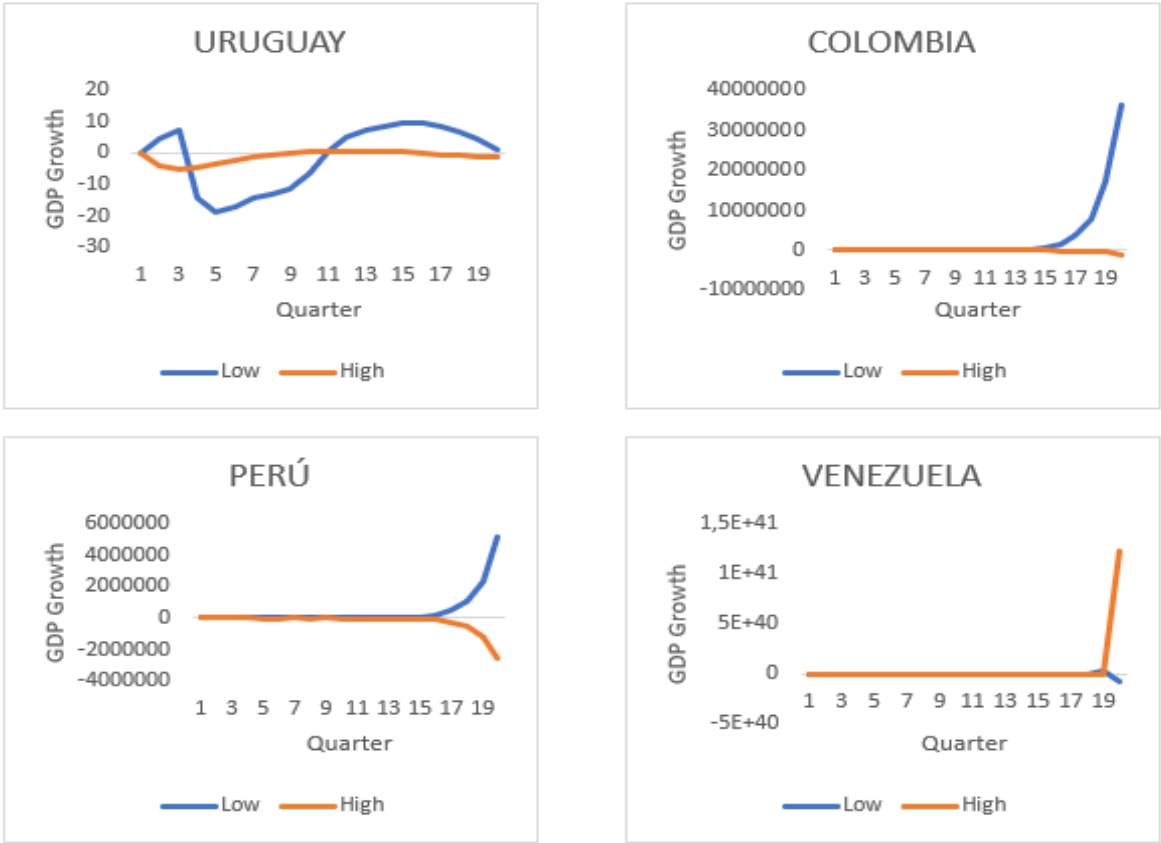
The graphs 5.17 and 5.18 describe the impulses responses function of GDP growth with respect of monetary shock of South American countries, considering of high and low inflation regime. We observe in Argentina that when the monetary shock occurs in a low inflation regime the effect on GDP is minimal, while when the shock occurs in a high inflation regime it causes GDP to have increasing variations and decreasing over time. The opposite occurs in Bolivia, the impact is minimal in the high inflation regime, and the GDP is volatile in the low regime, which fades over time. As for Brazil, the shock causes a decrease in GDP in both regimes, which is greater in the high regime. On the other hand, Chile's GDP has an unstable reaction with volatile movements in both regimes. Ecuador's GDP shows a negative reaction to an expansive monetary shock in both regimes; however, the impact is greater when inflation is on a rising regime. Paraguay presents a positive response to the shock, since in both regimes GDP grows in the short-term and stabilizes in the long-term. The GDP of Uruguay decreases immediately after the shock and stabilizes over time in the high regime, but it has a positive reaction after the shock in the low regime, following a downward trend for a couple of periods to an upward behaviour along the way. These results follow the dynamics of the research presented by Bernanke and Gertler (1989), Baumeister et al. (2008) and Caggiano et al. (2018).

Figure 5.17. Inflation Regime – M2 over GDP Shock: Impulse responses function of GDP growth (Part 1)



Source: Authors' calculations

Figure 5.18. Inflation Regime – M2 over GDP Shock: Impulse responses function of GDP growth (Part 2)

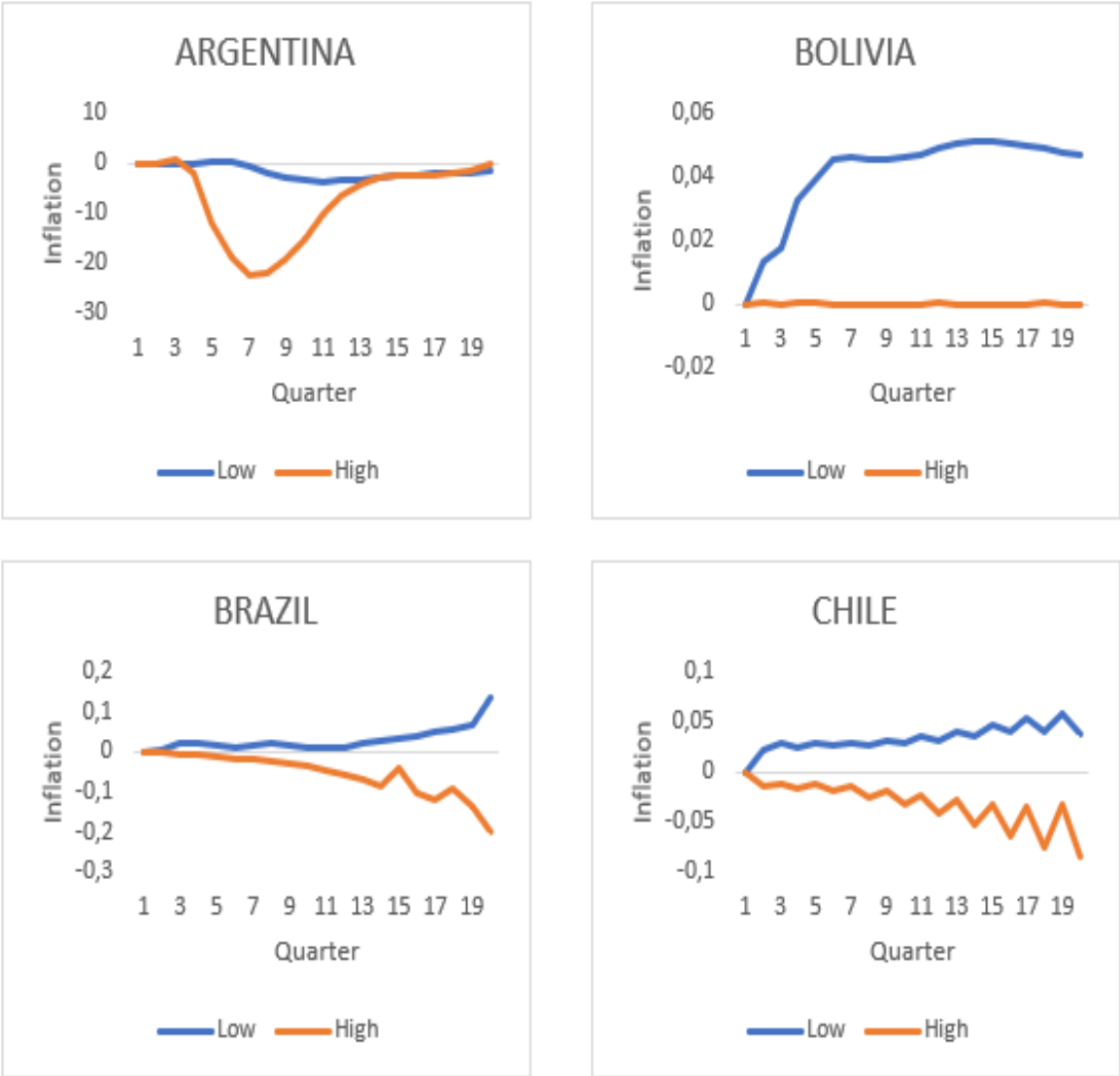


Source: Authors’ calculations

Impulse responses function of inflation

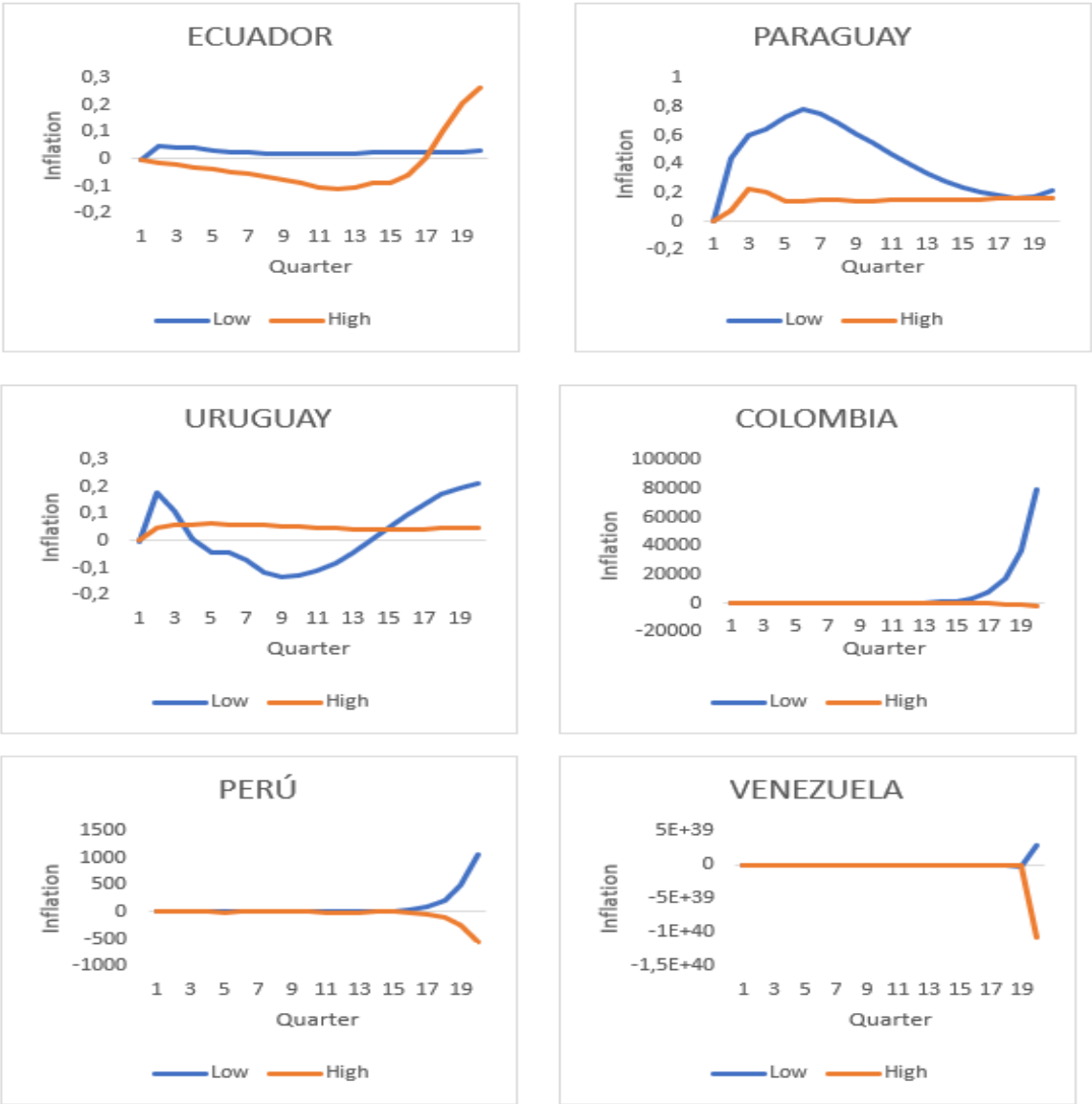
The graphs 5.19 and 5.20 describe the impulses responses function of inflation with respect of monetary shock of South American countries, considering of high and low inflation regime. The impulse response functions of inflation in the event of a shock in the M2 / GDP money supply in the TVAR model shows that there are inflationary pressures in a low regime in Bolivia, Brazil, Chile, Ecuador, Paraguay and Uruguay. This is a direct consequence of an increase in the money supply, which generates a decrease on interest rates, translated into a greater aggregate demand and higher prices of goods, so inflation increases in the same way. The inflation of Argentina in a low regime decreases from the sixth quarter in advance. In the high regime, there are deflationary pressures in Argentina, Brazil, Chile and Ecuador. This implies that when inflation in these countries is high, the phenomenon of Liquidity Traps occurs, so that the expansionary monetary policy does not act as expected in the different macroeconomic aggregates. In Bolivia, there is no inflation reaction in the high regime, while, in Paraguay and Uruguay, the monetary shock produces rising inflation. The results obtained follow the dynamics of the research presented by Grilli and Roubini (1996), Bigio and Salas (2008), Baumeister et al. (2008) and Caggiano et al. (2018)

Figure 5.19. Inflation Regime – M2 over GDP Shock: Impulse responses function of inflation (Part 1)



Source: Authors' calculations

Figure 5.20. Inflation Regime – M2 over GDP Shock: Impulse responses function of inflation (Part 2)

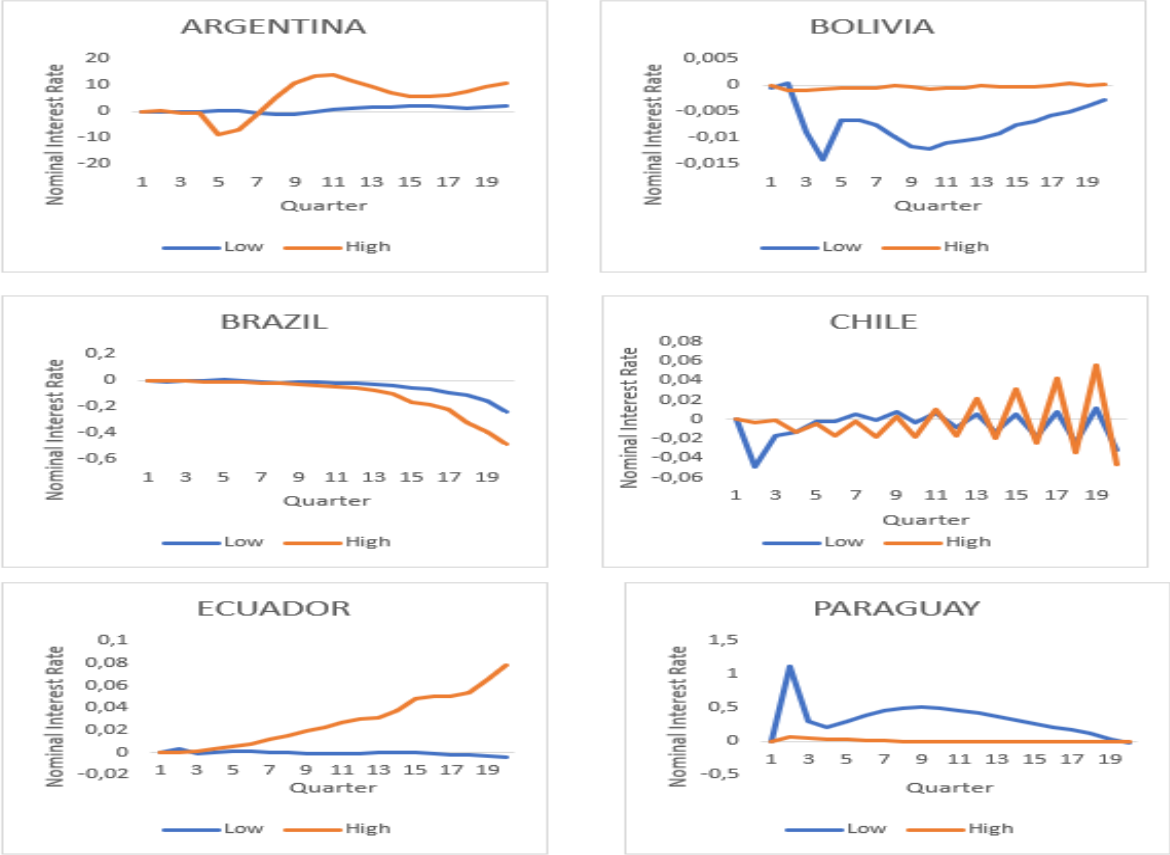


Source: Authors' calculations

Impulse responses function of the Nominal Interest rate

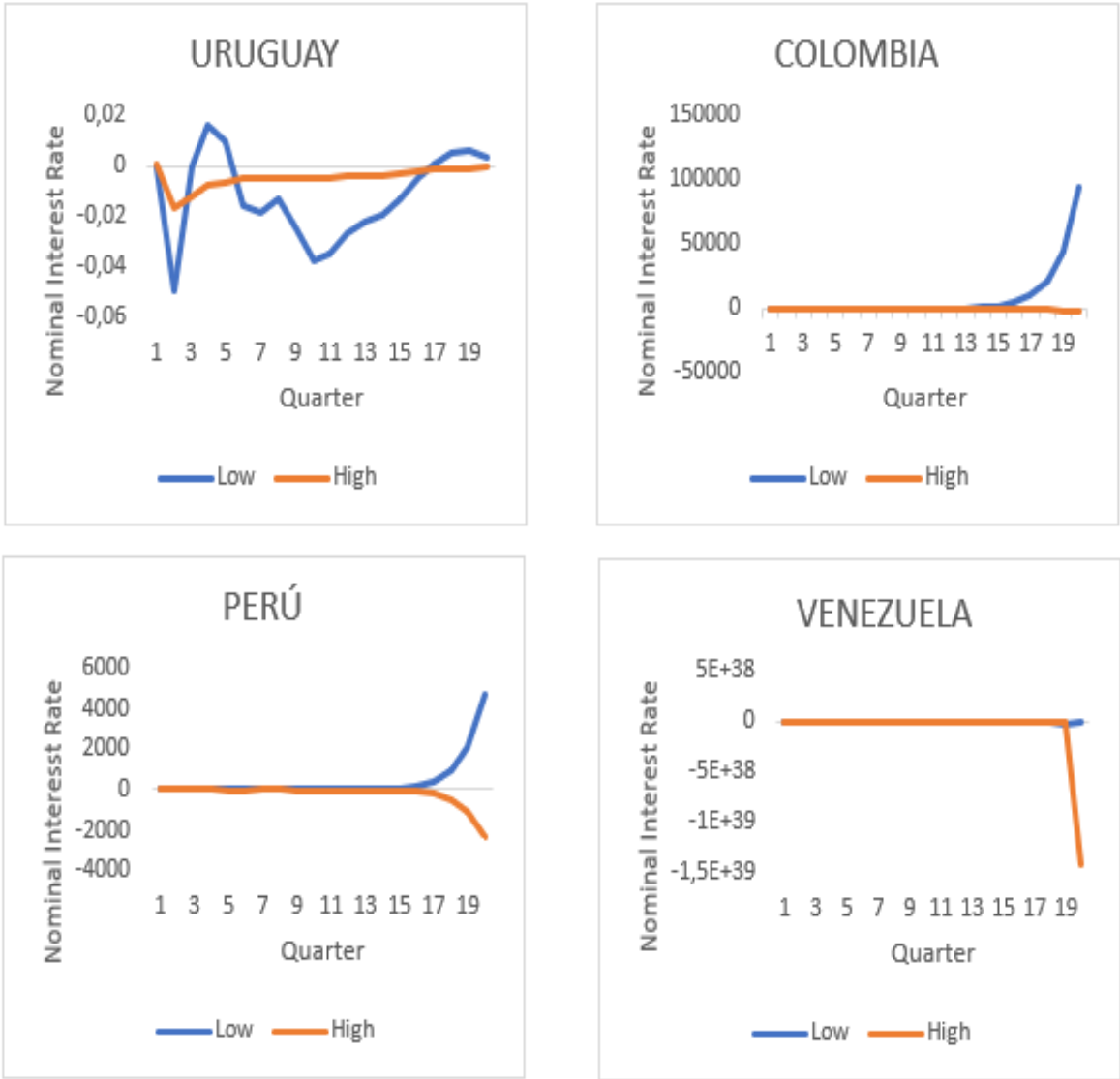
The graphs 5.21 and 5.22 describe the impulses responses function of the nominal interest rate with respect of monetary shock of South American countries, considering of high and low inflation regime. Argentina’s nominal interest rate to grow in the medium and long-terms in a high inflation regime, but the effect is almost null over time in a low inflation regime. The opposite happens in Bolivia: the impact is minimal in a high regime, while the shock produces a decrease in nominal interest rates in a low regime. In Brazil, the effect of a shock in both regimes leads to the nominal interest rate to falls; however, the impact is greater in the high regime. In the case of Chile, a monetary expansion produces a volatile response in the interest rate in both regimes, with a greater effect in the high regime. Ecuador’s interest rate increases after the shock in a high regime, and there is a null effect in a low regime. The opposite occurs in Paraguay, the monetary shock causes the nominal interest rate to grow greatly in a low regime and it has no effect in a high regime. Finally, in Uruguay we can see that a higher money supply produces the nominal interest rates to rise with greater magnitude in a low regime. Concisely, the nominal interest rate reacts according to the regime the economy is in at the time of the shock. When there is a decrease in the nominal interest rate, this can be attributed to the Liquidity Effects that indicate the existence of an inverse relationship between interest rates and the monetary policy Friedman (1968). The results obtained follow the dynamics of the research presented by Lucas (1990), Grilli and Roubini (1992), Baumeister et al. (2008) and Caggiano et al. (2018).

Figure 5.21. Inflation Regime – M2 over GDP Shock: Impulse responses function of Nominal Interest rate (Part 1)



Source: Authors’ calculations

Figure 5.22. Inflation Regime – M2 over GDP Shock: Impulse responses function of Nominal Interest rate (Part 2)

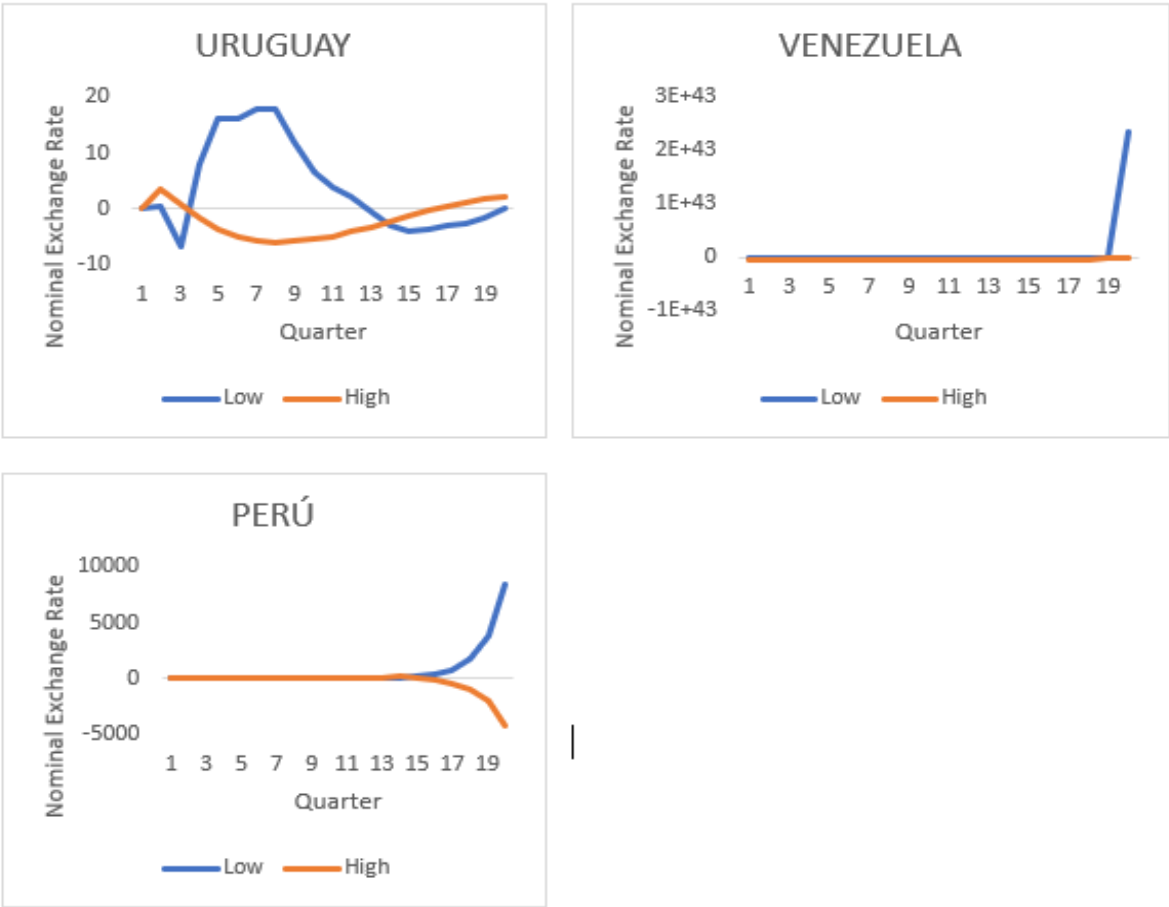


Source: Authors' calculations

Impulse responses function of the Nominal Exchange rate

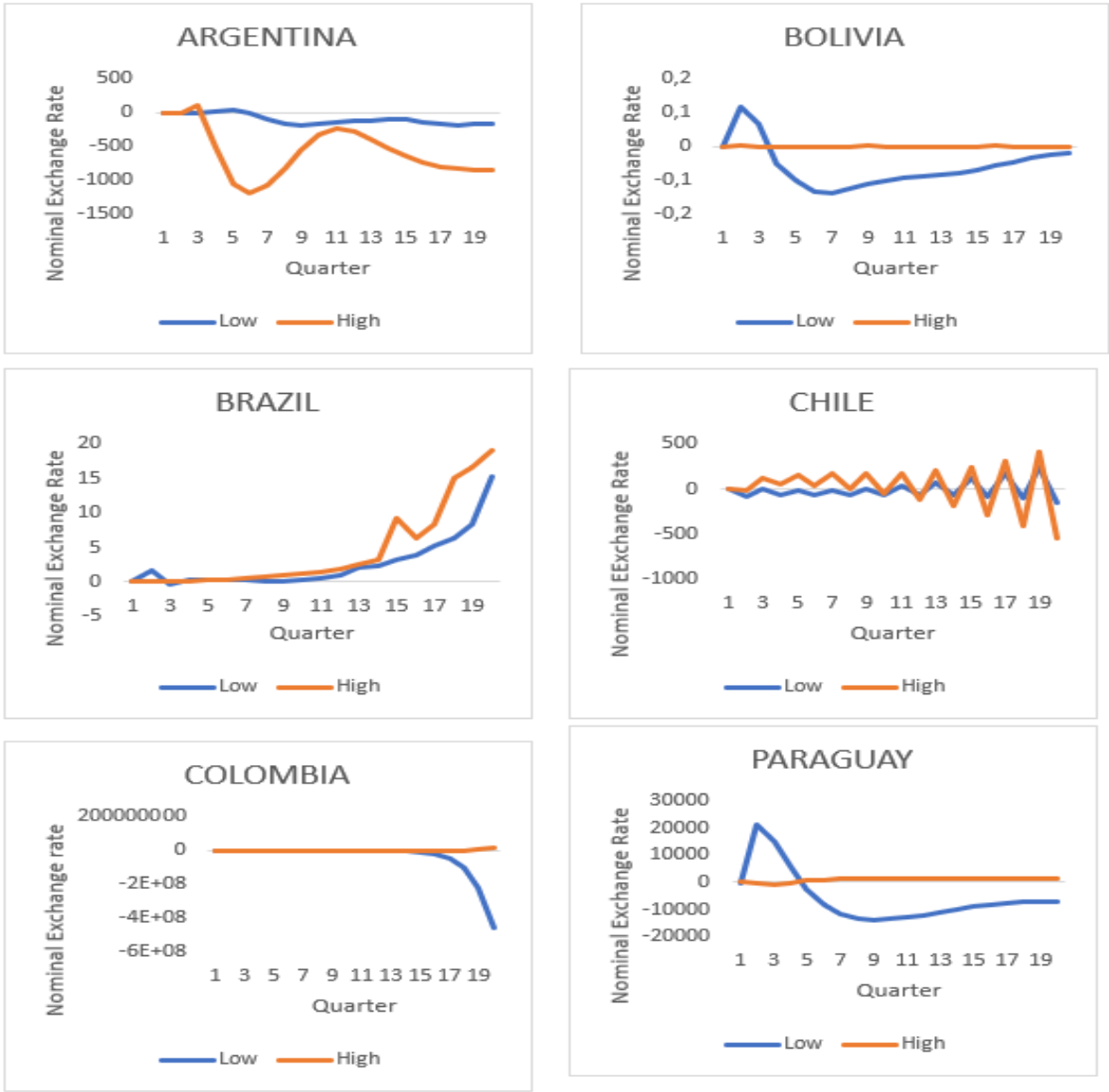
The graphs 5.23 and 5.24 describe the impulses responses function of nominal exchange rate with respect of monetary shock of South American countries, considering of high and low inflation regime. The monetary shock of Argentina causes the currency to depreciate in both regimes, however, the effect is greater when the shock occurs in the high inflation regime. In Bolivia and Paraguay, we note that the increase in the money supply does not have a significant effect in the high inflation regime, but there is an immediate appreciation of the currency in the low regime, followed by an abrupt depreciation in subsequent periods. Meanwhile, the nominal exchange rate in Brazil appreciates in both regimes after the shock; however, the effect is greater in magnitude in a high inflation regime. In Chile, we observe that the exchange rate has an unstable behavior characterized by volatile movements of the exchange rate over time. Lastly, in the case of Uruguay, the exchange rate has opposite effects in each regime. In a high inflation regime, the currency appreciates in the short-term and then depreciates in the medium-term; while in the low regime, in the short-term the exchange rate depreciates and in the medium term it appreciates to a greater extent than in the high regime. The results obtained are in accordance with the statements of Grilli and Roubini (1996) and Bigio and Salas (2008). They explained that liquidity shocks can affect the exchange rate through different transmission channels such as interest rates, or the level of inflation.

Figure 5.23. Inflation Regime – M2 over GDP Shock: Impulse responses function of Nominal Exchange Rate (Part 1)



Source: Authors’ calculations

Figure 5.24. Inflation Regime – M2 over GDP Shock: Impulse responses function of Nominal Exchange Rate (Part 2)



Source: Authors' calculations

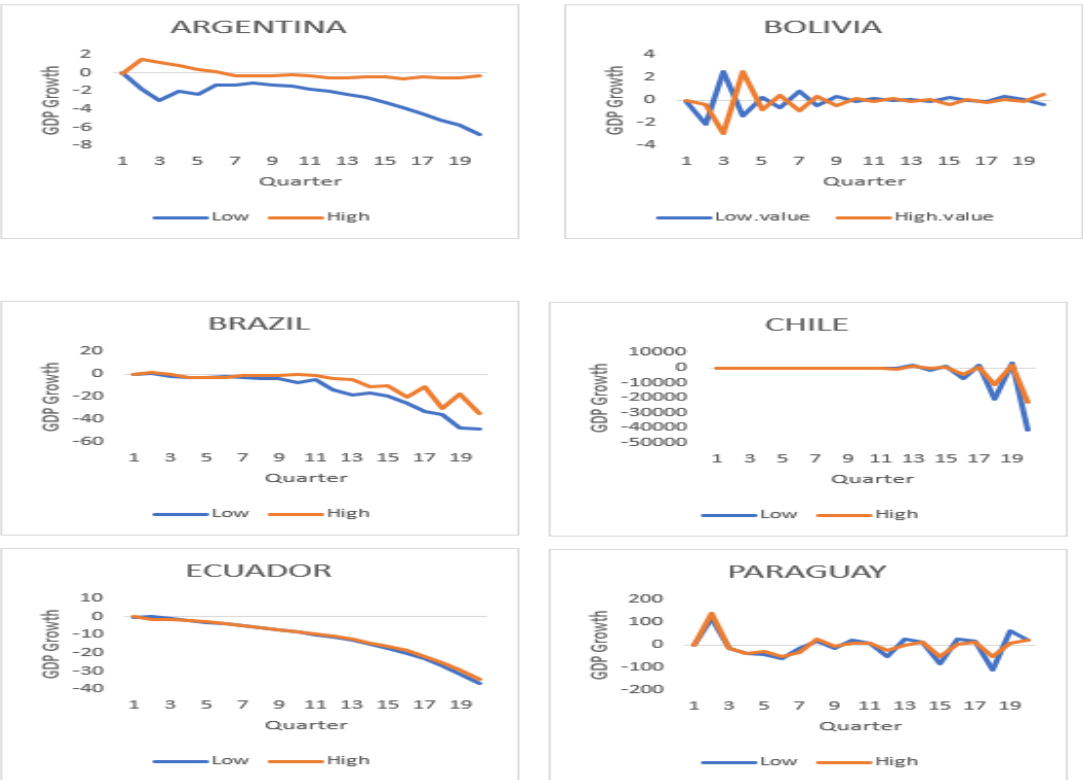
5.5.4. GDP GROWTH REGIME WITH M2/GDP SHOCK

Impulse responses function of GDP growth

The graphs 5.25 and 5.26 describe the impulses responses function of GDP growth with respect of monetary shock of South American countries, considering of high and low GDP growth regime. In the case of Brazil, Ecuador and Chile the reaction of GDP to a shock in M2 results on economic decrease in both regimes; however, GDP decreases more when the shock occurs during an economic contraction. In Argentina, we observe that, in the expansion regime, GDP increases in the short-term and then decreases and remains low on the long-term. In the low growth regime, the monetary shock causes the GDP to decrease, which continues to fall over time. In Bolivia, the response is volatile in the short-term with abrupt movements in both regimes, however, in the long-term GDP tends to stabilize. Paraguay’s GDP reacts in a similar way, whose behaviour is marked by a momentary growth after the shock, a fall and small rises and falls through time. Finally, in Uruguay, GDP grows exponentially over time on a low regime, while it decreases exponentially in the high regime.

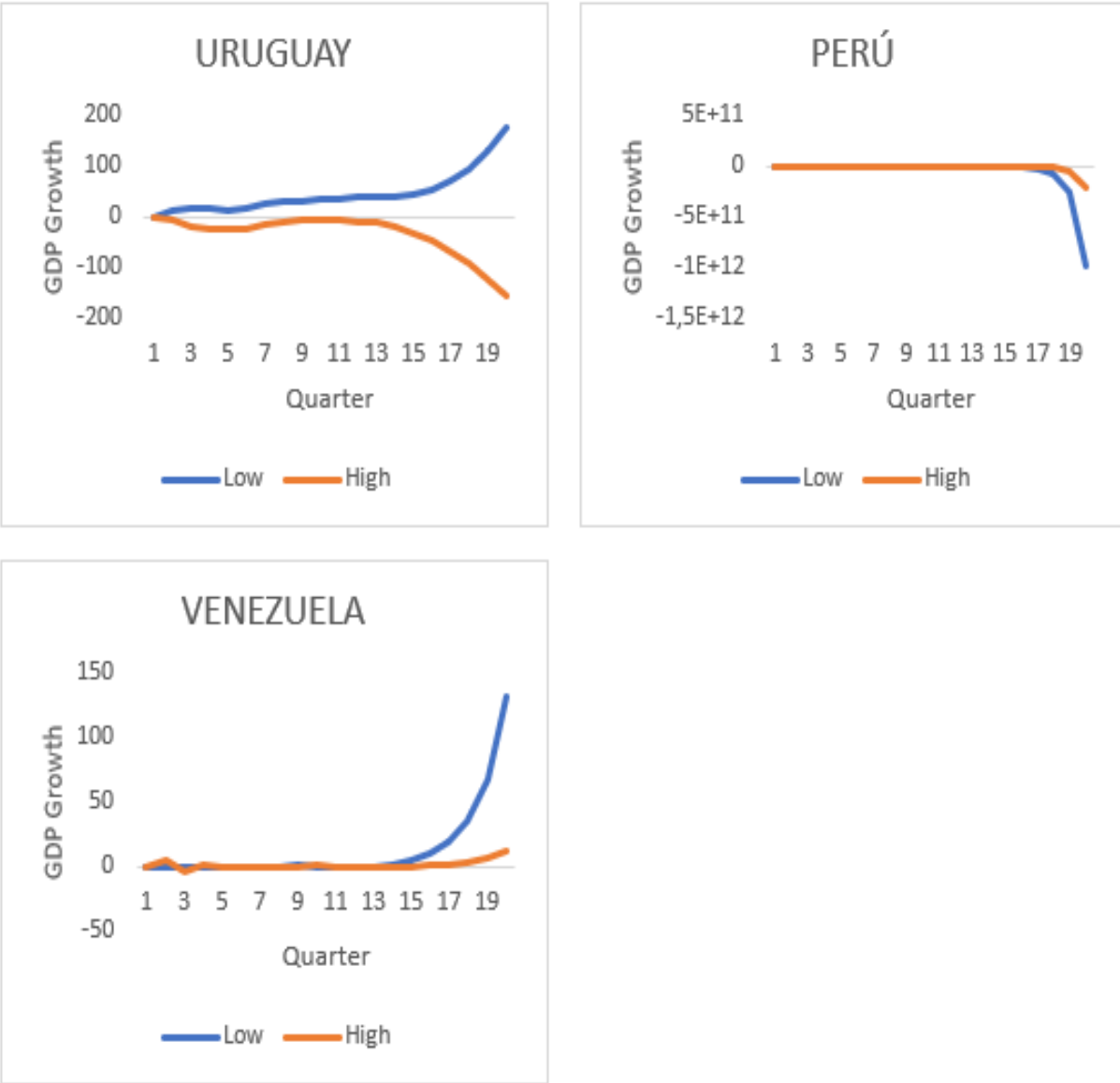
An expansion of the money supply has different effects, both in behaviour and in magnitude in the countries analyzed, however, this result is helpful to recognize in which situations it is advisable to take expansionary monetary policy actions. These results follow the dynamics of the results presented by Bernanke and Gertler (1989), Baumeister et al. (2008) and Caggiano et al. (2018).

Figure 5.25. GDP growth Regime – M2 over GDP Shock: Impulse responses function of GDP growth (Part 1)



Source: Authors’ calculations

Figure 5.26. GDP growth Regime – M2 over GDP Shock: Impulse responses function of GDP growth (Part 2)



Source: Authors’ calculations

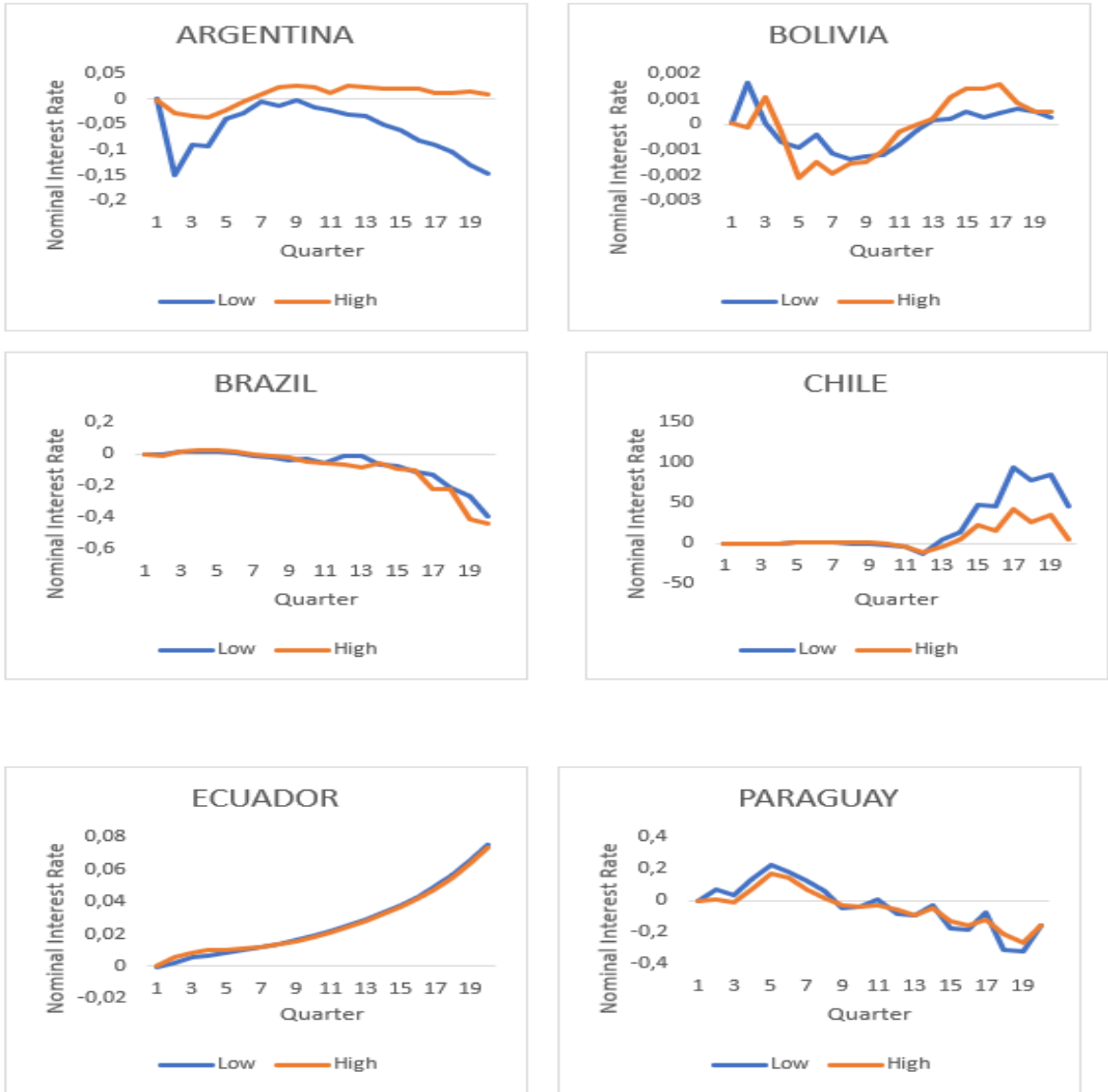
Impulse responses function of inflation

The graphs 5.27 and 5.28 describe the impulses responses function of inflation with respect of monetary shock of South American countries, considering of high and low GDP growth regime. We observe that inflation in Brazil and Chile behaves in a similar way, a null impact in both regimes in the short and medium-term, followed by deflationary pressures that are greater in the low economic growth regime. In Argentina, inflation increases continuously in the high economic growth regime, while it increases for two years and then it shows a downward trend in subsequent quarters, in the low growth regime. In Bolivia the main effect of the monetary shock is the rise in inflation in both regimes, with a greater magnitude in the high regime. The result of inflation in the face of a monetary shock in Ecuador and Paraguay is very similar, with deflationary pressures predominant in both regimes, the only difference is that in Paraguay there is a small growth in inflation in the short-term. The last one, Uruguay, shows opposite responses of inflation in both regimes, prices increase exponentially over time when the shock

occurs in a high economic growth, while they fall exponentially me on a low growth regime.

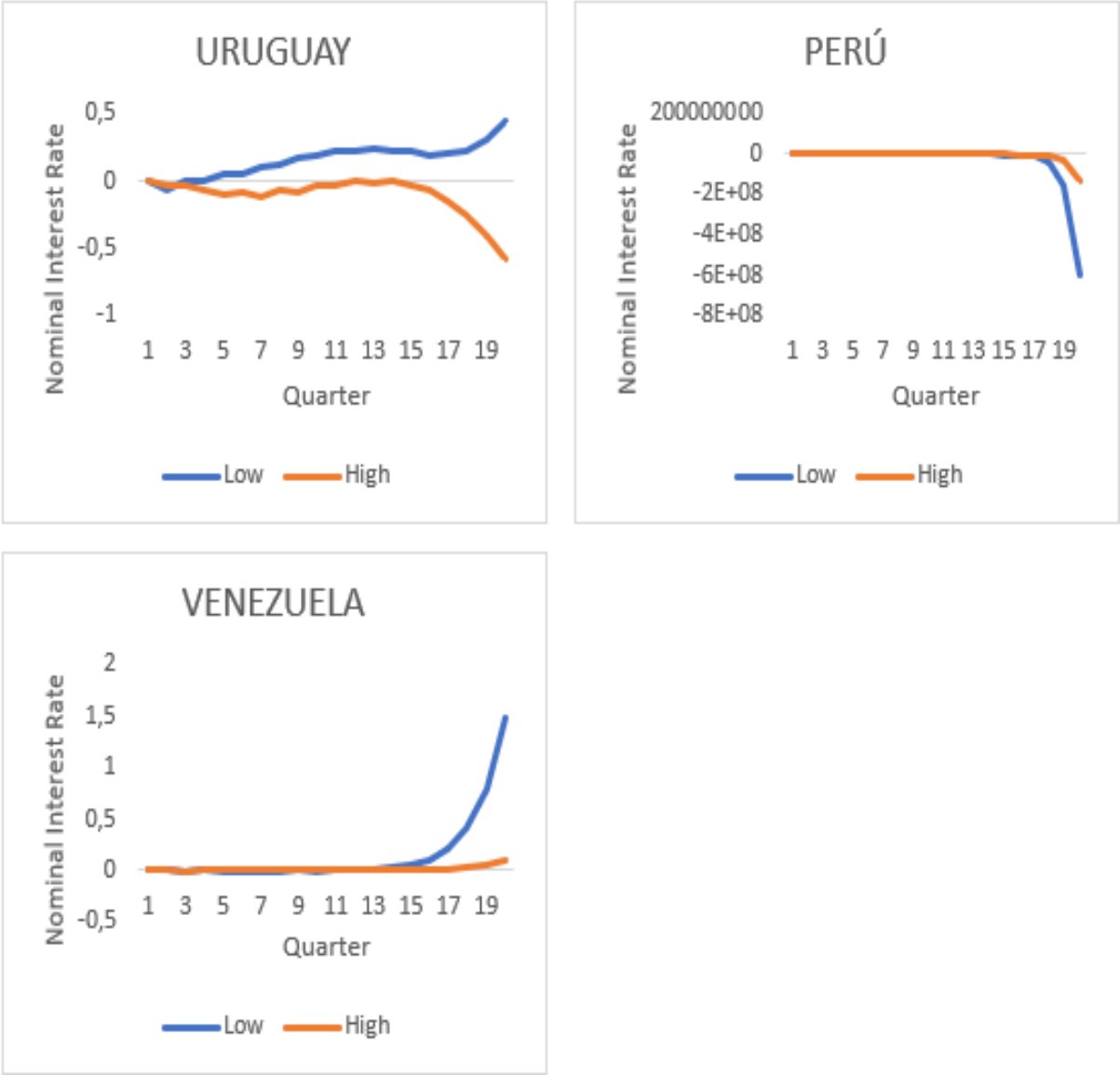
The results that imply rising inflation can be explained by the mechanism in which conventional monetary policy works, as the money supply increases, interest rates tend to decrease, causing a higher aggregate demand that is later translated into higher inflation. On the other hand, the observed deflationary effects can be explained by the phenomenon known as the Liquidity Trap, where monetary policy does not produce the expected effect on interest rates, and therefore, the result of a monetary expansion does not increase inflation. These results are in accordance with the statements of Grilli and Roubini (1996), Bigio and Salas (2008), Baumeister et al. (2008) and Caggiano et al. (2018).

Figure 5.27. GDP growth Regime – M2 over GDP Shock: Impulse responses function of Nominal Interest Rate (Part 1)



Source: Authors' calculations

Figure 5.28. GDP growth Regime – M2 over GDP Shock: Impulse responses function of Nominal Interest Rate (Part 2)



Source: Authors’ calculations

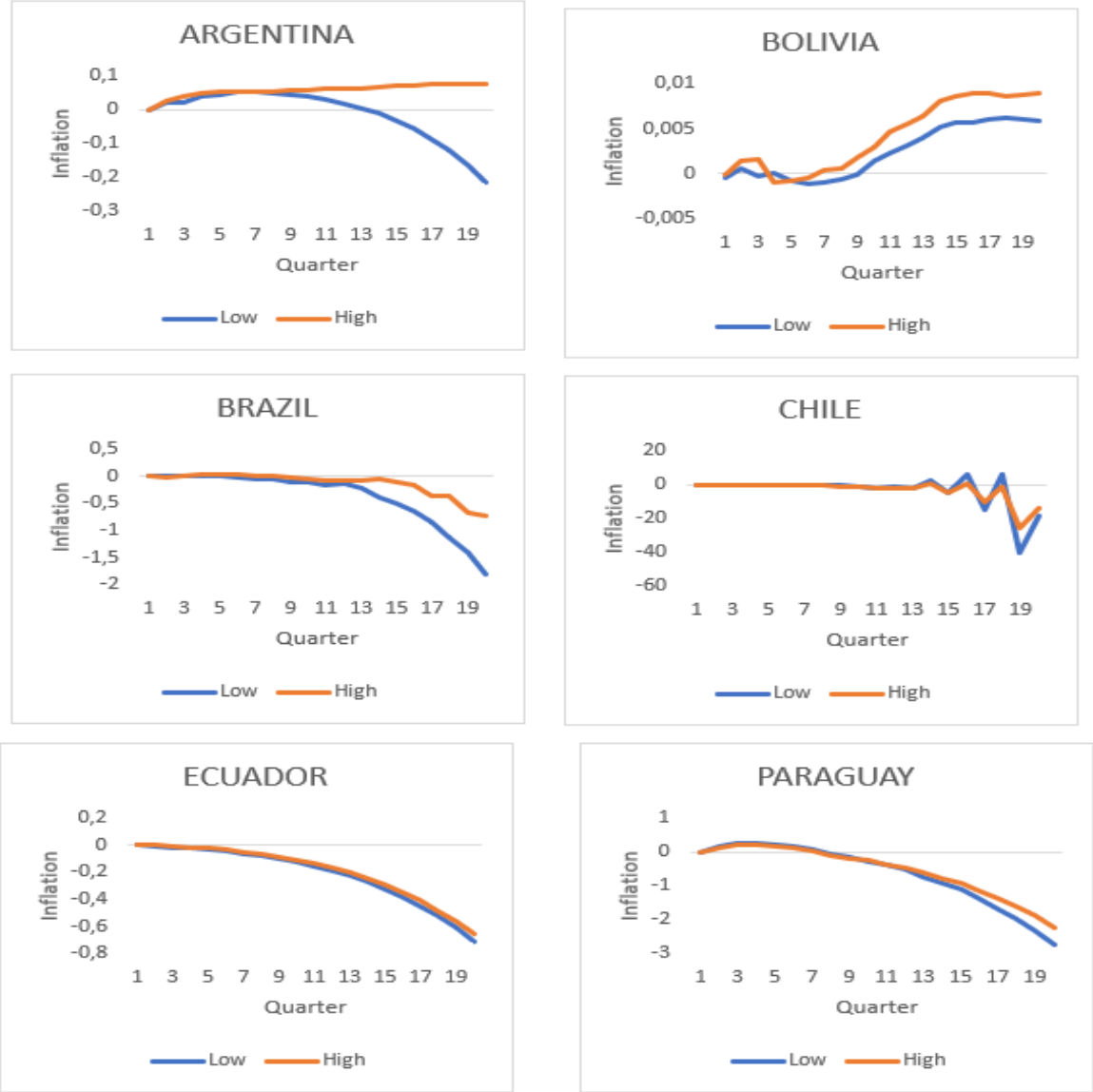
Impulse responses function of nominal interest rate

The graphs 5.29 and 5.30 describes the impulses responses function of nominal interest rate with respect of monetary shock of South American countries, considering of high and low GDP growth regime. Argentina’s nominal interest rate decreases in the short-term in both regimes, with a greater extent in the low-growth regime. Subsequently, in the high regime, interest rates rise and remain stable since the ninth quarter, while in the low regime it increases until the tenth quarter and then shows a downward trend. In Bolivia, the effect of an increase in the money supply is initially a higher nominal interest rate, changing to a downward trend in the medium-term, following rising interest rates in the long-term. This dynamic corresponds to both GDP regimes. In Brazil, responses of the nominal interest rate are similar in both regimes, at the time of the shock it is not affected, but on the medium and long term the nominal interest rate show a decreasing trend. The result of a positive monetary shock in Chile’s nominal interest rate is null until the tenth quarter, after it increases in both regimes, to a greater extent

during a low economic growth. Likewise, in Ecuador the nominal interest rate increases exponentially in both regimes. In Paraguay, the effect of the shock produces an increase in the nominal interest rate in the short-term, followed by a decrease in the medium and long term, this behaviour is reflected in both regimes, but with the difference that the effect is greater in magnitude in the low mode. Finally, in Uruguay there is an opposite dynamic of the interest rate in the face of a monetary shock, in the low regime, the interest rate increases over time, while in the high regime it decreases.

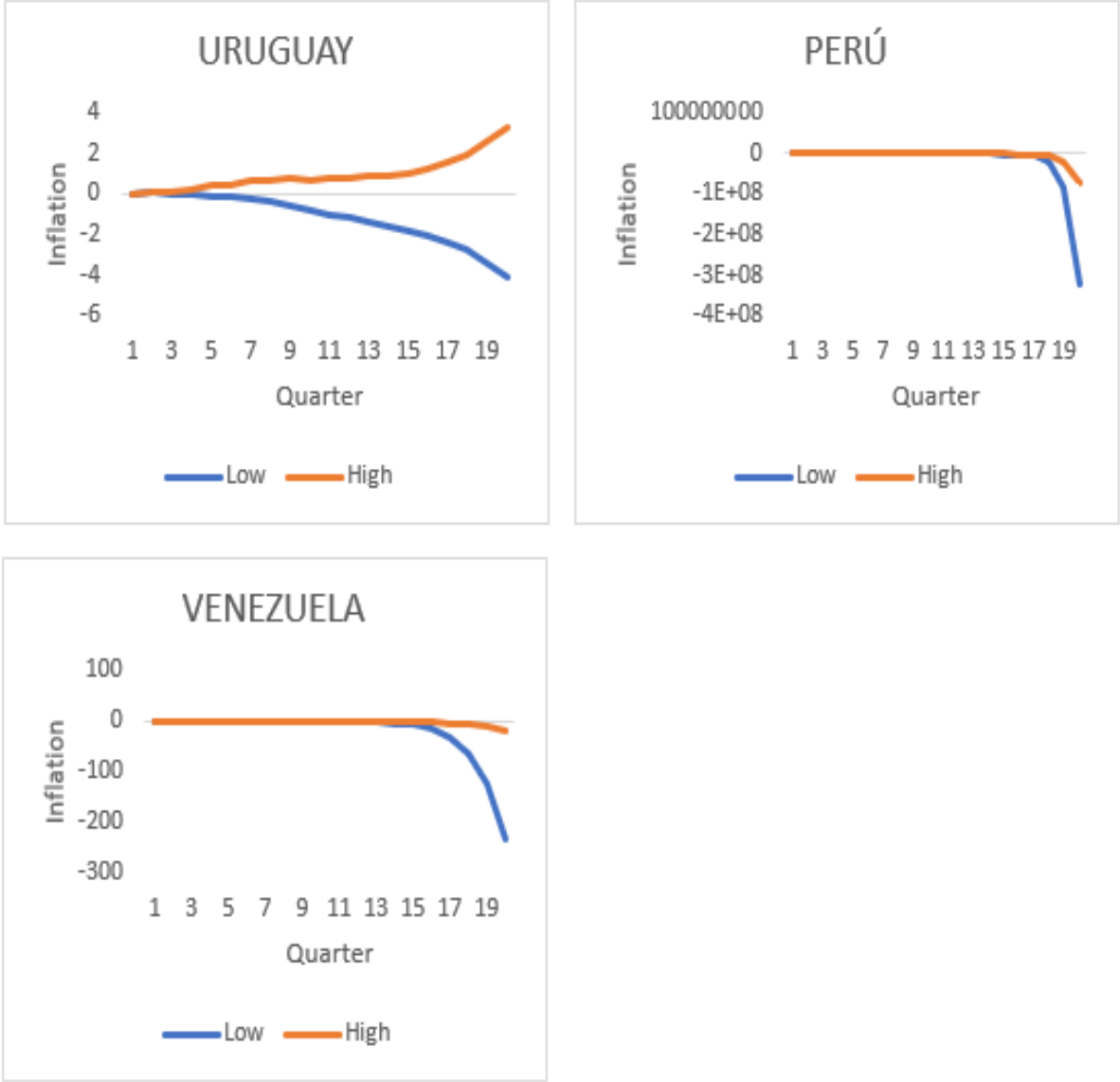
The decrease in the interest rate responds to the fact that a monetary expansion causes the people’s spending to increase in the short-term due to the lower value of the loan. Whereas the increase in the interest rate can be explained by the existence of interest rates that are too small, which cause conventional monetary policy measures to have no effect on the economy, therefore, the behaviour of rates is not the expected one (Ugarte and León, 2017).

Figure 5.29. GDP growth Regime – M2 over GDP Shock: Impulse responses function of inflation (Part 1)



Source: Authors’ calculations

Figure 5.30. GDP growth Regime – M2 over GDP Shock: Impulse responses function of inflation (Part 2)



Source: Authors' calculations

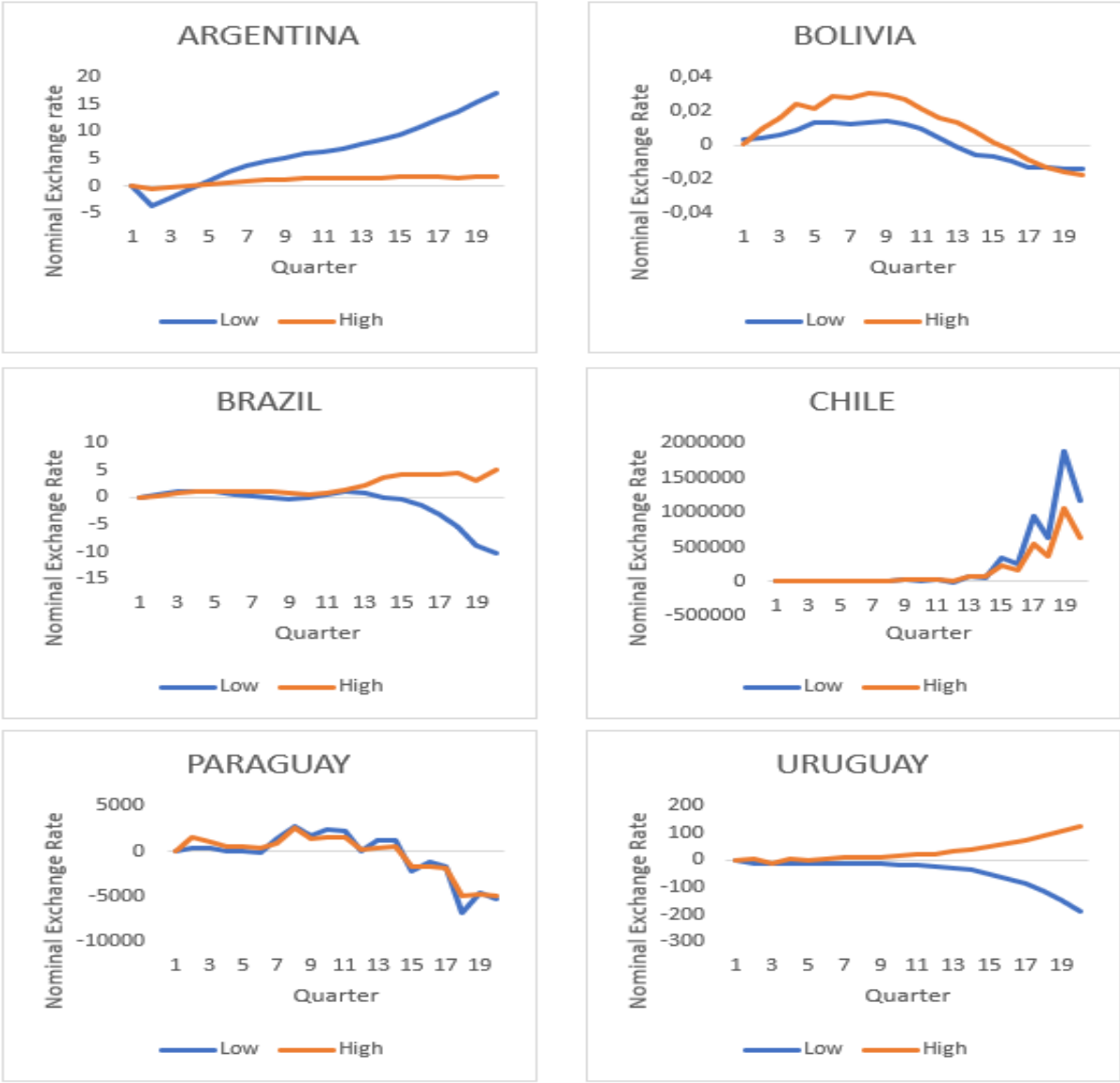
Impulse responses function of Nominal Exchange rate

The graphs 5.31 and 5.32 describes the impulses responses function of nominal interest rate with respect of monetary shock of South American countries, considering of high and low GDP growth regime. The impulse-response functions of the nominal exchange rate show a similar behaviour in Uruguay and Brazil. In a regime of economic expansion, the exchange rate grows over time after a monetary shock, while in the regime of economic contraction, the exchange rate decreases. Likewise, in Paraguay and Bolivia the currency appreciates in the medium term, followed by a period of depreciation, a similar behaviour in both regimes; however, the proportion is higher in the regime of high economic growth. On the other hand, in Argentina, an expansive monetary shock causes an appreciation of the exchange rate in a regime of high economic growth, and produces an immediate depreciation of the exchange rate in a low growth regime, to later appreciate in a higher proportion.

The results obtained are in accordance with what was stated by Grilli and Roubini (1996) and Bigio

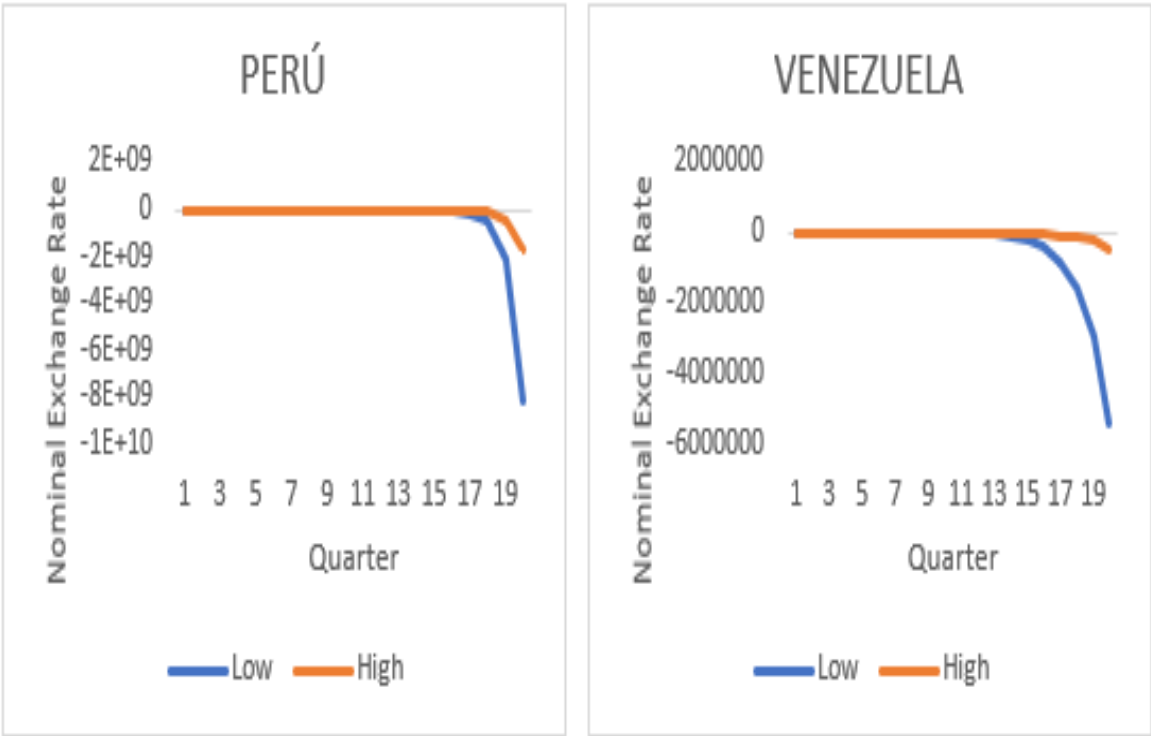
and Salas (2008). They explain that liquidity shocks can affect the exchange rate through different transmission channels such as interest rates, or the level of inflation.

Figure 5.31. GDP growth Regime – M2 over GDP Shock: Impulse responses function of Nominal Exchange Rate (Part 1)



Source: Authors' calculations

Figure 5.32. GDP growth Regime – M2 over GDP Shock: Impulse responses function of Nominal Exchange Rate (Part 2)



Source: Authors' calculations

5.6. CONCLUSIONS

The purpose of this research is to contribute with a practical study to the debate on the monetary and liquidity shocks that an economy can suffer at any given time and its possible future behavior through a liquidity and monetary risk monitoring system, using the Threshold Variable Autoregression Model (TVAR), adopting two regimes, and capturing the existence of non-linearities to obtain the asymmetries between responses of shocks.

The aim of this research is to obtain stress scenarios through thresholds that determine limits, identifying thresholds according to inflation and economic growth regimes, considering the behaviour of macroeconomic variables related to the shocks analyzed by the literature, which serve as a predictive guide to delineate the macro-prudential policies in the South American region. The analysis was carried out considering two possible scenarios: a situation of rising inflation (high inflation regime) versus a deflation period (low inflation regime), and a scenario of economic expansion (high GDP growth regime) versus an economic slowdown (low GDP growth regime). We carried out an exercise in 10 South American countries in which the behavior of key macroeconomic variables, such as inflation, economic growth, nominal interest and exchange rate. To measure shocks and define the inflation and economic growth regimes, we used the liquid assets to short-term liabilities ratio for the liquidity shock and the ratio between M2 and GDP to evaluate the monetary shock.

Our results are robust and consistent since the variables used show non-linearity in most of the countries, except Colombia with respect to the economic growth regime both in the non-linearity test - Hansen

regimes and in the Wald test that determines the threshold if there is no non-linearity. In addition, the thresholds obtained for each country analyzed are significant, except Colombia. The predictions obtained by the impulse function show a projection of the behaviour of the liquidity and monetary shock in the face of inflation and GDP growth regimes for each country evaluated over a period of 58 quarters.

The exercise showed that a positive liquidity shock on GDP growth in a context of inflation regime, has different effects between the countries taken into account, with both positive and negative results depending on the interactions of the variables included in the model. Inflation response to a liquidity shock showed a similar behavior in Bolivia, Chile, Paraguay and Uruguay where the inflationary effect was greater when the shock occurred in the low inflation regime compared to the high one. On the other hand, in Ecuador there were inflationary pressures in the high regime while inflation decreases over the estimated time in a low regime. In Argentina and Brazil, the response of inflation weak in the short term. The response of the nominal interest rate to a positive liquidity shock considering inflation regime depends on the state of the economy at the time of the shock. A decrease of the nominal interest rate can be attributed to liquidity effect that indicate the existence of an inverse relationship between interest rates and the monetary policy. The impulse-response function of the nominal exchange rate to a change in liquidity showed different effects on each country. In Argentina and Uruguay, in a low inflation regime the exchange rate does not have a significant effect, while with high inflation it tends to depreciate. In Bolivia, Brazil, Chile and Paraguay, the exchange rate does not have great variations in the high regime, but large depreciation occurs and tends to recover in the long-term when analyzing a low inflation regime.

A liquidity shock on economic growth regime has different dynamics on each country with both positive and negative effects. This result depends on the interactions of the different variables included in the model, as well as on the history presented between liquidity and individual GDP growth. In a group of countries, the effect of a positive liquidity shock is mainly characterized by a decrease in inflation while another group is distinguished by the existence of inflationary pressures in the face of a liquidity shock. The response of the nominal interest rate and of the exchange rate to a positive liquidity shock depends on the state of the economy at the time of the shock, which is why it is verified that there are asymmetric relationships between the different variables macroeconomics of Latin American countries.

An expansion of the money supply has different effects between the countries analyzed, both in behavior and magnitude, depending on the interactions of the variables included in the model and the regime under examination. However, this result is helpful to recognize in which situations it is advisable to take expansionary monetary policy actions. The results that imply rising inflation and decreasing interest rates can be explained by the mechanism in which conventional monetary policy works, as the money supply increases, interest rates tend to decrease, causing a higher aggregate demand that is later translated into higher inflation, this was the case of Argentina and Uruguay in the short term and Brazil in the long term. On the other hand, the observed deflationary effects and rising interest rates can be explained by the phenomenon known as the Liquidity Trap, where monetary policy does not produce the expected effect on interest rates, and therefore, the result of a monetary expansion does not increase inflation. This was the case for Ecuador in both the short and long term, Argentina in the long term, Paraguay in the short and medium term. On the other hand, Chile and Bolivia present a monetary shock with respect to the volatile interest rate in both the short and long term.

In the case of Venezuela, it was possible to identify the thresholds in both the inflation and economic growth regimes, but in view of the fact that this country presents an economic decline, a high degree of inflation and a depreciation of its currency, and even considering an increase in its liquidity, it does

not present changes in the two regimes in the short and medium term. In the same way, if there is a monetary injection, inflation, GDP growth, nominal exchange rate and nominal interest rate do not show any reaction in the short and medium term. In the long term, although liquidity or money is injected and there may even be deflation, economic decline and currency depreciation persist.

Finally, the South American region shows a high degree of sensitivity to liquidity and monetary shocks. Therefore, the response to the impulse of both an inflation or deflation regime and an economic expansion or contraction regime motivates the continuous monitoring of liquidity and monetary risk to macroeconomic shocks, this proves that it is important to use a method that identifies risk thresholds considering the multivariate interaction without the need for the behaviour to be linear, but at the same time this will depend on the introduction of additional variables or periods that continue to maintain this relationship.

6. Conclusions

South American economies have shown different stages of contraction and expansion. The decade of the 1980s, or “the lost decade”, was the period when most South American countries experienced economic downturns accompanied by high levels of indebtedness, high inflation, and many of these economies opted to devalue their currencies to increase their export revenues. In addition, countries such as Brazil, Argentina and Ecuador experienced a banking crisis in the late 1990s and early 2000s due to domestic over-indebtedness, rising interest rates and financial speculation. On the other hand, several South American countries experienced stability between 2003 and 2007 due to higher commodity prices, reduced external indebtedness and the accumulation of international reserves. Despite the global financial crisis of 2008-2009, South American economies did not present impacts on their balance of payments or inflationary problems, even though GDP growth contracted at the beginning of 2008, but as a response, countercyclical monetary and credit policies were applied (Ocampo, 2000) (Ocampo and Martin, 2003) (Ocampo, 2009) (Ocampo and Titelman, 2009) (Ocampo, 2014) (Ocampo, 2015) (Ocampo 2002, Ocampo 2009, Ocampo 2015).

The economic growth of South American countries experienced a stagnation from 2014 with the decrease in commodity prices, decreasing -0.7 percent in 2015, -1.5 percent in 2016. By 2017 there was a recovery in the prices of several metals and oil. As a consequence, both Argentina and Brazil experienced a modest growth and in general the region reached 1.7 percent growth. However, this decreased for 2018, since South American economies just reached 1 percent of growth due to countries such as Argentina contracted its economy, on the other hand Brazil only presented a moderate recovery and Venezuela presented a decrease both 2018 and 2019 (Végh et al., 2019).

In view of the fact that South American economies have experienced periods of economic and financial vulnerability, the objective of this thesis is to identify the level of macro-social-financial risk by constructing an index that measures the level of uncertainty, building sub-indicators that evaluate macroeconomic risk, solvency, liquidity, market and social development, are considering in order to later analyse if there is a systemic contagion in the South American region according to the level of macroeconomic and financial risk in relation to commercial and financial globalization, and finally to monitor the liquidity and monetary risk are monitored by constructing stress scenarios through thresholds considering high and low inflation and economic growth regimes.

Chapter 2 provides a thorough review of the literature on the economic and financial vulnerability. Economic vulnerability identifies the level of uncertainty that economies are exposed to internal and external macroeconomic and/or financial shocks considering economic and financial openness, export concentration, peripherality and dependence on strategic imports (Briguglio, 1995) (Briguglio and Galea, 2003). In addition, (Guillaumont, 2009) also mentions that it is important to consider the role of geography and size in determining the magnitude of vulnerability. (Guillaumont, 2009), (Cardona, 2007) (Baritto, 2008) include the environmental impacts as other sources as other vulnerability sources as well as external shocks aspects related to external demand reflected in trade and the exchange rate, interest rate fluctuations and the variation in the prices of financial instruments such as commodities. In this context, other authors such as (Cordina, 2004), (Baritto, 2009), (Briguglio et al., 2009), (Essers, 2013) and (Essers, 2015) mention that macroeconomic vulnerability is also generated by market imperfections and financial instabilities.

When uncertainty increases in intensity, it can lead to a crisis. On the one hand, (Kindleberger, 1978)

mentioned that the crisis should be evaluated in a general way and should not be subdivided into types of crises. On the other, (Kaminsky, 1999),(Bussière and Fratzscher, 2006), (Reinhar and Rogoff, 2011), (Laeven et al., 2012) and (Bordo and Meissner, 2016) described that crises generate a high cost and these can be a cause of other internal or external crises, which can be linked not only by economic or monetary uncertainties, but also financial uncertainties related to the banking sector, the stock market and sovereign indebtedness.

Considering this, chapter 3 identifies periods of crisis and/or vulnerability through an early warning model in order to measure the level of macro-social-financial risk of 10 South American countries from 1978 to 2014. This vulnerability index was constructed through the partial least squares structural equation model and, unlike other indexes, it is also composed of a sub-indicator that evaluates social development risk, in addition to sub-indicators that analyse macroeconomic, liquidity, solvency and market risk. Using the calculated index, we proceeded to construct an uncertainty thermometer to determine the cut-off points of the high and low level of the risk, considering three classification methods: the linear discriminant analysis (LDA), K-nearest neighbours (KNN) and super vector machine (SVM). As a result, it was confirmed that the machine learning methods presented the highest level of accuracy at the predictive classification and the best level of the precision, and by means of the standard deviation and the centroids were possible to identify in each country and in each year the sub-zones of high risk (unmanageable, intolerable and unstable) and low risk (manageable, moderate, stable and strong). The results are robust and consistent, given that the macroeconomic-social-financial index captures periods of high uncertainty presented in the lost decade, since most of the countries evaluated present intolerable and unstable risk in 1982, 1983, 1985 and 1989 according to (Herrera and Garcia, 1999), (Bértola and Ocampo, 2012). Furthermore, this analysis confirms the periods of high instability in the late 1990s and early 2000s, where banking crises occurred, also identified by (Reinhart, 2010), (Laeven et al., 2012) and (Bordo and Meissner, 2016). Most of the South American economies showed a manageable, moderate, and stable level of macro-social-financial risk in the period 2005 to 2011, due to the increase in commodity prices and increases in fiscal revenues (Ocampo, 2014) (Ocampo, 2014). On the other hand, Venezuela experienced high macro-financial uncertainty since 2011 and Argentina presented macro-financial instability problems since 2014 (Ocampo, 2014) and (IMF, 2016).

Most authors who evaluate crisis contagion in chapter 2 mention that the probability of contagion can occur due to the propagation of economic and financial shocks because of periods of vulnerability or crisis from one country to another, considering that crises can cause deep and lasting recessions and the impacts of periods of vulnerability could spread rapidly to other countries (Rigobon, 1999), (Essers, 2013), (Claessens et al., 2014). In addition, (Masson, 1998) and (Valdés and Hernández, 2001) have assessed that the level of contagion depends on the impact of shocks generated by transmission channels between countries during periods of crisis. Bilateral transmission channels are mostly reflected through capital flows linked to trade openness (trade globalization) and financial openness (financial globalization) (Kaminsky and Reinhart, 2000), (Lane and Milesi-Ferretti, 2003). Since trade liberalization has led countries to become competitive, they have opted for currency devaluation as a strategy, in search of an increase in the trade market and capital flows, which have had an impact on economic growth but also generated macroeconomic volatility, since a national economy becomes more vulnerable to greater external risk (Newbery and Stiglitz, 1984), (Rodrik, 1997) and (Valdés and Hernández, 2001). While contagion through financial linkages depends on financial market behavior reflected in cross-country direct investments that depend on corporate and financial sector returns, foreign investors' liquidity problems and information asymmetries.

In view of the fact that the most South American countries have had liquidity problems caused by over-indebtedness in the dead decade and banking crises in the late 1990's and early 2000's, both Argentina and Venezuela have experienced increasing inflation and economic decline and most countries have proceeded to devalue their currencies to increase the competitiveness of their export products. In recent years, both Argentina and Venezuela have experienced increasing inflation and economic decline and most countries have proceeded to devalue their currencies to increase their competitiveness of their export products and this has caused them to adjust their liquidity levels. Given this, our study proposes to build a stress system, which identifies the liquidity and monetary effects on macroeconomic shocks considering stressing scenarios through a high or low inflation and GDP growth regime, using the Threshold Vector Autoregressive Model (TVAR) non-linear model in South American countries for the period between 2006Q1 and 2020Q2. The main finding, when evaluating the liquidity impact through the indicator liquidity assets to short term liabilities on the delays GDP growth and inflation, presents a non-linear interaction that shows that when inflation increases, it also increases the liquid assets to cover the short-term debt under the high and low inflation regime in most countries. The response of inflation to a liquidity shock showed similar behavior in Bolivia, Chile, Paraguay and Uruguay where the inflationary effect was greater when the shock occurred in the low inflation regime. In Argentina and Uruguay, in a low inflation regime, the exchange rate does not have a significant effect, whereas, with high inflation, the nominal exchange rate in some countries tends to devalue or depreciate. In Bolivia, Brazil, Chile and Paraguay, the exchange rate does not vary greatly in the high-inflation regime, but there is a large depreciation that tends to recover in the long term when a low-inflation regime is analyzed. On the other hand, as the money supply increases, interest rates tend to decrease, leading to higher aggregate demand which then translates into higher inflation. This was the case in Argentina and Uruguay in the short term and in Brazil in the long term. In addition, Chile and Bolivia present a monetary shock with respect to the volatile interest rate in both the short and long term. The results obtained follow the dynamics of the research presented by (Grilli and Roubini, 1996), (Bigio and Salas, 2008), (Baumeister et al., 2008) and (Caggiano et al., 2018).

6.0.1. LIMITATIONS AND AVENUES FOR FUTURE RESEARCH

This dissertation analyzed the macroeconomic and financial vulnerability of the 10 South American countries focusing on an assessment at the macro and regional level, with the aim of contributing to the formulation of macro-prudential policies in the region, through the identification, measurement of macro-social-financial uncertainty, monitoring of systemic macro-financial risk contagion and follow-up through stress tests focused on liquidity and monetary risk in the face of high and low inflation and GDP growth regimes. Annual and quarterly data were taken into account, which led to monitoring macro-financial systemic risk contagion and follow-up through stress tests focused on liquidity and monetary risk in the face of high and low inflation and GDP growth regimes. In addition, annual and quarterly data obtained through the databases of the International Monetary Funds, World Bank and each central bank of each of the countries was also considered. In view of the fact that different methodologies were used, both the construction of the macro-financial risk index and the analysis of systemic contagion before the interconnection of country's economic cycle synchronization, bilateral trade, and trade agreement linkages among 10 South American countries were placed through a panel evaluation that limits to an individual risk analysis.

Identifying the level of macro-financial risk standardized at regional level was , limited to distinguish the uncertainties at micro level, so for future research will proceed to build the vulnerability index of each

country using data at provincial level and focused not only on general vulnerabilities but also local ones related to fiscal and productive uncertainties. In addition, consider indicators or information related to macroeconomic risk, market risk, liquidity, solvency, for future research we will introduce more variables related to social vulnerability and environmental vulnerability, in order to assess resilience as suggested by (Baritto, 2008), (Briguglio et al., 2009), (Briguglio, 2013), and (Essers, 2015).

In the case of the systemic contagion risk assessment, it was limited only to identifying the regional interconnection only of South America, where the trade concentration and the intensity of capital flows with countries outside this region, where South America maintains high levels of exports and imports, were not visualized. For this purpose, a future non-standardized panel analysis will be proposed through an individual assessment between the 10 countries versus the USA, China and the European Union, considering not only the three connection links evaluated, but also the flow of foreign investment and capital.

The identification of liquidity and monetary risk thresholds proposed through the TVAR methodology allowed capturing non-linear relationships, given that the behavior of most macro and financial variables are not seasonal. In addition, this methodology predicted limits according to the non-linear interaction of high or low inflation regimes reflected in macroeconomic and financial shocks. However, in the case of Colombia it was not possible to determine any of the regimes, since it presented limitations such as a linear relationship with the behavior of macroeconomic and financial indicators, as well as. The fact that if a variable is removed or introduced, the methodology cannot be standardized in all countries. For future research, solvency risk will be evaluated, given that currently with the pandemic crisis most South American countries have increased their level of indebtedness and not only thresholds will be identified with non-linear techniques but also with linear techniques.

Finally, the pandemic crisis has caused an economic slowdown in South American economies, which leads central banks to identify, measure, monitor the probability of contagion and develop stress tests considering internal and external shocks, in order to develop and manage macroprudential policies to minimize the identified risks.

7. Appendices

A. Appendices to chapter 3

A.1. APPENDIX

Table A.1.1. Definition of Variables and Data Source

Variable	Definition	Source	
Macroeconomic variables			
XME1	Inflation, GDP deflator (annual %)	Inflation as measured by the annual growth rate of the GDP implicit deflator shows the rate of price change in the economy as a whole. The GDP implicit deflator is the ratio of GDP in current local currency to GDP in constant local currency.	World Bank, World Development Indicators (WDI)
XME2	GDP growth (annual %)	Annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2010 U.S. dollars. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products.	World Bank, World Development Indicators (WDI)
XME3	Growth of primary sector (% of GDP)	The primary sector is concerned with the extraction of raw materials. It includes fishing, farming and mining on GDP.	ECLAC: Economic Commission for Latin America and the Caribbean
XME4	Growth of secondary sector (% of GDP)	The secondary sector includes secondary processing of raw materials, food manufacturing, textile manufacturing and industry on GDP.	ECLAC: Economic Commission for Latin America and the Caribbean
XME5	Growth of tertiary sector (% of GDP)	The tertiary sector of industry involves the provision of services to other businesses as well as final consumers on GDP.	ECLAC: Economic Commission for Latin America and the Caribbean
XME6	Growth of Exports of goods and services (annual %)	Annual growth rate of exports of goods and services based on constant local currency. Aggregates are based on constant 2010 U.S. dollars. Exports of goods and services represent the value of all goods and other market services provided to the rest of the world.	World Bank, World Development Indicators (WDI)
XME7	Cash surplus/deficit (% of GDP)	Cash surplus or deficit is revenue (including grants) minus expense, minus net acquisition of nonfinancial assets. This cash surplus or deficit is closest to the earlier overall budget balance (still missing is lending minus repayments, which are now a financing item under net acquisition of financial assets).	International Monetary Fund, Government Finance Statistics Yearbook and data files, and World Bank and OECD GDP estimates.
XME8	Foreign direct investment, net outflows (% of GDP)	Foreign direct investment refers to direct investment equity flows in an economy. It is the sum of equity capital, reinvestment of earnings, and other capital. This series shows net outflows of investment from the reporting economy to the rest of the world, and is divided by GDP.	World Bank, World Development Indicators (WDI)
XME9	Foreign direct investment, net inflows (% of GDP)	Foreign direct investment are the net inflows is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. This series shows net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors, and is divided by GDP.	World Bank, World Development Indicators (WDI)
XME10	Fiscal Revenue, excluding grants (% of GDP)	Revenue is cash receipts from taxes, social contributions, and other revenues such as fines, fees, rent, and income from property or sales.	Using the data of the World Development Indicators (WDI)
Solvency variables			
XS1	Total Debt (% GDP)	Total Debt to GDP	International Monetary Fund, Government Finance Statistics
XS2	External Debt (% GDP)	Total external debt, as a % of GDP, annual average. It refers to debt owed to nonresidents by residents.	Inter-American Development Bank, LMW data and Latin Macro watch calculations based on each central bank.

Table A.1.1. Definition of Variables and Data Source

	Variable	Definition	Source
XS3	Central government debt, total (% of GDP)	Debt is the entire stock of direct government fixed-term contractual obligations to others outstanding on a particular date. It includes domestic and foreign liabilities such as currency and money deposits, securities other than shares, and loans. It is the gross amount of government liabilities reduced by the amount of equity and financial derivatives held by the government.	World Bank, World Development Indicators (WDI)
XS4	Total debt service (% of exports of goods, services and primary income)	Total debt service to exports of goods, services and primary income. Total debt service is the sum of principal repayments and interest actually paid in currency, goods, or services on long-term debt, interest paid on short-term debt, and repayments (repurchases and charges) to the IMF.	World Bank, World Development Indicators (WDI)
XS5	Gross public debt (% of GDP)	General government gross debt according to the convergence criteria set out in the Maastricht Treaty comprises currency, bills and short-term bonds, other short-term loans and other medium- and long-term loans and bonds	Inter-American Development Bank. Historical IDB Debt Database (HIDD) and CLYPS debt database.
Liquidity variables			
XL1	Broad money (% of GDP)	Broad money is the sum of currency outside banks; demand deposits other than those of the central government; the time, savings, and foreign currency deposits of resident sectors other than the central government; bank and traveler's checks; and other securities such as certificates of deposit and commercial paper.	World Bank, World Development Indicators (WDI)
XL2	Total reserves (% of total external debt)	International reserves to total external debt stocks.	World Bank, World Development Indicators (WDI)
XL3	Liquid liabilities (% of GDP)	Ratio of liquid liabilities to GDP. Liquid liabilities are also known as broad money, or M3. They are the sum of currency and deposits in the central bank (M0), plus transferable deposits and electronic currency (M1), plus time and savings deposits, foreign currency transferable deposits, certificates of deposit, and securities repurchase agreements (M2), plus travelers checks, foreign currency time deposits, commercial paper, and shares of mutual funds or market funds held by residents.	International Financial Statistics (IFS) of Bank International of Settlements (BIS) and International Monetary Fund (IMF)
XL4	Broad money to total reserves ratio	Broad money is the sum of currency outside banks; demand deposits other than those of the central government; the time, savings, and foreign currency deposits of resident sectors other than the central government; bank and traveler's checks; and other securities such as certificates of deposit and commercial paper.	World Bank, World Development Indicators (WDI)
XL5	Central Bank Assets to GDP	Ratio of central bank assets to GDP. Central bank assets are claims on domestic real nonfinancial sector by the Central Bank.	Federal Reserve Bank USA Economic Data
Market variables			
XM1	Real effective exchange rate index	Real effective exchange rate is the nominal effective exchange rate (a measure of the value of a currency against a weighted average of several foreign currencies) divided by a price deflator or index of costs.	World Bank, World Development Indicators (WDI)
XM2	Capital stock price	Price level of the capital stock, price level of USA in 2011=1. It is built up from investment data by asset of firms of each country.	The data-set is available at www.ggdc.net/pwt , Feenstra et al. (2015).
XM3	Domestic credit to private sector (% of GDP)	Domestic credit to private sector refers to financial resources provided to the private sector by financial corporations, such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment.	World Bank, World Development Indicators (WDI)
XM4	Market capitalization of listed domestic companies (% of GDP)	Market capitalization (also known as market value) is the share price times the number of shares outstanding (including their several classes) for listed domestic companies. Investment funds, unit trusts, and companies whose only business goal is to hold shares of other listed companies are excluded.	World Bank, World Development Indicators (WDI)
Social Development			
XD1	Mortality rate, under-5 (% 1,000 live births)	Under-five mortality rate is the probability per 1,000 that a newborn baby will die before reaching age five, if subject to age-specific mortality rates of the specified year.	World Bank, World Development Indicators (WDI)

Table A.1.1. Definition of Variables and Data Source

	Variable	Definition	Source
XD2	Poverty Gap 1,90 (% of population)	Poverty gap at \$1.90 a day (2011 PPP) is the mean shortfall in income or consumption from the poverty line \$1.90 a day (counting the nonpoor as having zero shortfall), expressed as a percentage of the poverty line. This measure reflects the depth of poverty as well as its incidence.	World Bank, World Development Indicators (WDI)
XD3	Government expenditure on education, total (% of GDP)	General government expenditure on education (current, capital, and transfers) is expressed as a percentage of GDP.	World Bank, World Development Indicators (WDI)
XD4	High-technology exports (% of manufactured exports)	High-technology exports are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.	World Bank, World Development Indicators (WDI)
XD5	Health expenditure, total (% of GDP)	Total health expenditure is the sum of public and private health expenditure. It covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health but does not include provision of water and sanitation.	World Bank, World Development Indicators (WDI)
Dummy Crisis			
XC1	Inflation crisis	Reinhart and Rogoff define inflation crises as episodes where annual inflation exceeds 20%.	This database includes data of Reinhart and Rogoff (2010).
XC2	All crisis	This dummy variable integrate the information of currency crisis periods, banking crisis dummy and sovering debt crisis dummy obtained in Bordo and Meissner (2016) and Laeven and Valencia (2012).	Data Notes from Bordo and Meissner (2016). This database includes data of Laeven and Valencia (2012).

Source: World Bank, IMF, IADB and Central Banks

A.2. APPENDIX

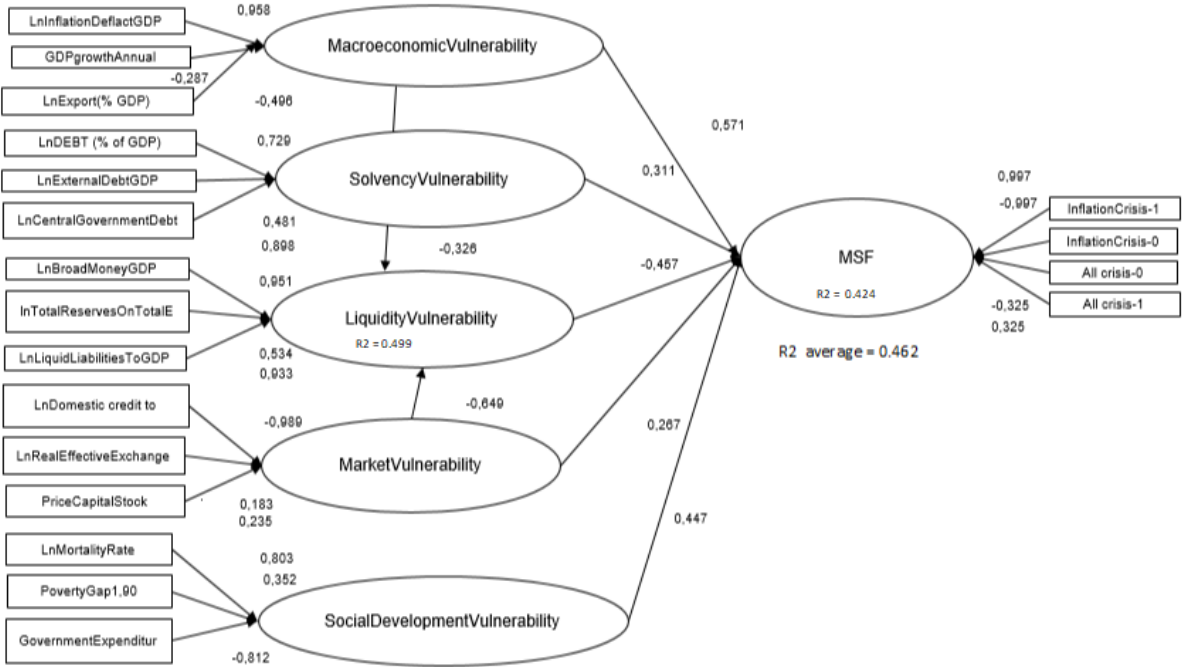
Table A.2.2. Descriptive Statistics

Descriptive statistics (All observables variables proposed)							
Code	Min	Max	Mean	SD	Skew	Kurtosis	VIF
XME1	-3.50	9.42	2.68	1.78	0.16	2.67	1.27
XME2	-9.50	11.98	3.27	4.20	-0.73	0.84	4.38
XME3	-49.58	34.24	2.84	6.36	-1.33	14.78	1.14
XME4	-17.48	30.70	2.76	6.21	-0.16	1.85	2.90
XME5	-15.69	23.33	3.43	4.43	-0.52	2.57	2.14
XME6	1.62	4.12	3.06	0.52	-0.13	-0.34	1.23
XME7	-16.60	12.16	-1.36	4.01	-0.52	0.48	1.24
XME8	-3.54	8.03	0.40	1.02	4.17	24.78	1.50
XME9	-2.50	12.20	2.26	2.39	1.66	3.07	1.73
XME10	9.78	32.16	20.03	4.54	0.13	-0.54	1.08
XS1	1.36	5.32	3.70	0.62	-0.39	0.84	2.25
XS2	2.43	4.95	3.66	0.47	-0.06	-0.53	2.11
XS3	2.19	5.06	3.74	0.52	-0.27	-0.41	2.23
XS4	1.69	4.96	3.56	0.51	-0.79	1.36	1.15
XS5	1.34	4.96	3.78	0.60	-0.91	1.46	2.66
XL1	2.31	4.71	3.46	0.47	0.07	-0.13	3.60
XL2	0.84	6.13	3.32	0.91	0.24	-0.03	1.78
XL3	1.50	4.34	3.30	0.45	-0.46	0.73	2.91
XL4	-0.08	1.69	0.45	0.26	0.88	1.52	1.72
XL5	0.00	50.21	8.93	9.40	1.65	2.89	1.03
XM1	3.54	6.12	4.57	0.37	0.58	1.43	1.19
XM2	0.21	1.31	0.48	0.19	2.17	6.35	1.18
XM3	2.17	4.90	3.35	0.56	0.21	-0.42	1.34
XM4	-23.21	157.05	19.51	28.96	1.99	3.94	1.32
XD1	2.06	5.19	3.49	0.69	0.31	-0.43	1.62
XD2	0.26	24.04	6.75	4.95	0.99	1.30	1.73
XD3	0.03	21.16	6.58	4.81	1.16	0.19	1.27
XD4	-2.28	4.01	1.38	0.86	-1.10	3.02	1.30
XD5	1.22	2.75	1.83	0.32	0.22	-0.16	1.69
XC1	0.00	1.00	0.43	0.50	0.30	-1.92	1.07
XC2	0.00	1.00	0.22	0.41	1.36	-0.14	1.07

Source: Authors' calculations

A.3. APPENDIX

Figure A.3.1. The path diagram of the best model



Source: Authors' calculations

A.4. APPENDIX

Table A.4.3. Evaluation results for each predictive model over the train data-set (10-fold CV averages)

Classification Methods	Precision=0	Precision=1	Recall=0	Recall=1	F-Measure=0	F-Measure=1	Accuracy	Type I	Type II	ROC	NSR	Global Classification
LDA	0.976	0.966	0.984	0.950	0.980	0.958	0.972	0.023	0.033	0.967	0.034	0.973
KNN	0.946	0.946	0.976	0.883	0.961	0.914	0.945	0.054	0.053	0.922	0.056	0.945
SVM	0.976	0.966	0.984	0.950	0.980	0.958	0.972	0.023	0.033	0.967	0.034	0.973

Note: these ratios are evaluation measures' averages for each method, on the predictions on the test sets (10-fold CV) of the training data-set
Source: Authors' Calculations

A.5. APPENDIX

Table A.5.4. MSF global index

ID	YEAR	COUNTRY	Subindicator Macroeconomic Vulnerability Indicator	Subindicator Solvency Vulnerability Indicator	Subindicator Market Vulnerability Indicator	Subindicator Liquidity Vulnerability Indicator	Subindicator Social Development Vulnerability Indicator	Subindicator Crisis Latente	MSF GLOBAL INDEX	MSF Binary K-means
1	1978	ARGENTINA	1,87	-1,93	1,05	-1,46	0,83	1,10	1,93	1
2	1979	ARGENTINA	1,68	-1,06	0,77	-1,17	0,69	1,10	1,88	1
3	1980	ARGENTINA	1,68	-1,02	0,68	-1,18	0,6	1,27	2,04	1
4	1981	ARGENTINA	1,79	-0,18	0,22	-1,03	0,65	1,27	2,11	1
5	1982	ARGENTINA	1,98	0,31	0,34	-1,49	0,62	1,27	2,34	1
6	1983	ARGENTINA	2,13	0,12	0,67	-1,94	0,58	1,10	2,30	1
7	1984	ARGENTINA	2,5	0,77	0,89	-2,13	0,43	1,10	2,54	1
8	1985	ARGENTINA	2,48	0,82	1,45	-2,98	0,56	1,10	2,82	1
9	1986	ARGENTINA	1,25	0,49	1,49	-2,4	0,55	1,10	2,32	1
10	1987	ARGENTINA	1,64	0,8	1,03	-1,92	0,51	1,27	2,48	1
11	1988	ARGENTINA	2,24	0,48	1,17	-1,94	0,23	1,10	2,38	1
12	1989	ARGENTINA	3,26	1,48	-0,39	-1,36	0,51	1,27	2,71	1
13	1990	ARGENTINA	3,07	0,22	1,69	-4,06	0,48	1,27	3,31	1
14	1991	ARGENTINA	1,5	-0,13	2,03	-4,16	-0,21	1,27	2,76	1
15	1992	ARGENTINA	0,32	-0,39	1,6	-2,95	-0,16	-0,88	-0,06	0
16	1993	ARGENTINA	-1,66	-0,62	1,19	-1,3	-0,31	-0,88	-1,06	0
17	1994	ARGENTINA	-0,38	-0,74	0,89	-1,28	-0,27	-0,88	-0,77	0
18	1995	ARGENTINA	1,44	-0,25	0,81	-1,28	0,45	1,10	1,92	1
19	1996	ARGENTINA	-1,1	-0,14	0,66	-0,77	0,42	-0,88	-0,86	0
20	1997	ARGENTINA	-1,16	-0,13	0,52	-0,36	0,49	-0,88	-0,97	0
21	1998	ARGENTINA	-1,07	-0,02	0,36	-0,06	-0,08	-0,88	-1,13	0
22	1999	ARGENTINA	2,3	0,23	0,51	-0,22	0,66	0,31	1,21	1
23	2000	ARGENTINA	1,98	0,2	0,58	-0,13	0,73	0,31	1,12	1
24	2001	ARGENTINA	1,6	0,3	0,61	-0,3	1,69	1,27	2,24	1
25	2002	ARGENTINA	2,2	2,37	0,92	-0,92	1,86	1,27	2,91	1
26	2003	ARGENTINA	0,41	2,14	1,58	-1,06	1,21	1,10	2,20	1
27	2004	ARGENTINA	-0,44	1,69	1,79	-1,24	-1,22	-0,71	-0,34	0
28	2005	ARGENTINA	-0,45	1,07	1,66	-1,03	-1,53	-0,71	-0,56	0
29	2006	ARGENTINA	-0,21	0,79	1,49	-1,02	-1,71	-0,71	-0,60	0
30	2007	ARGENTINA	-0,16	0,51	1,37	-0,95	-1,75	-0,71	-0,67	0
31	2008	ARGENTINA	0,1	0,34	1,54	-1,45	-1,93	-0,71	-0,53	0
32	2009	ARGENTINA	0,41	0,5	1,51	-1,24	-1,97	0,31	0,53	1
33	2010	ARGENTINA	-0,06	0,06	1,5	-1,28	-1,89	-0,88	-0,82	0
34	2011	ARGENTINA	0,22	-0,07	1,37	-1,38	-1,96	-0,88	-0,78	0
35	2012	ARGENTINA	0,44	0,11	1,27	-1,18	-1,81	-0,88	-0,72	0
36	2013	ARGENTINA	0,51	0,38	1,19	-1,18	-1,94	-0,88	-0,70	0
37	2014	ARGENTINA	0,94	0,58	1,86	-2	-2,08	1,27	1,84	1
38	1978	BOLIVIA	-0,05	0,77	0,79	-1,56	1,55	-0,71	0,15	0
39	1979	BOLIVIA	0,23	0,82	0,74	-1,7	1,52	0,31	1,27	1
40	1980	BOLIVIA	0,28	0,9	0,84	-1,66	1,5	0,31	1,29	1
41	1981	BOLIVIA	0,21	0,92	0,91	-1,66	1,48	0,31	1,28	1
42	1982	BOLIVIA	1,21	1,21	0,16	-1,35	1,46	1,10	2,21	1
43	1983	BOLIVIA	1,49	1,62	0,98	-2,49	1,44	1,10	2,69	1
44	1984	BOLIVIA	2,4	1,52	1,3	-3,48	1,42	1,10	3,17	1
45	1985	BOLIVIA	3,67	2,14	0,72	-4,61	1,39	1,10	3,77	1
46	1986	BOLIVIA	1,54	2,77	1,35	-3,93	1,34	1,27	3,38	1
47	1987	BOLIVIA	0,02	2,66	1,04	-2,16	1,34	-0,88	0,38	1

Table A.5.4. MSF global index

ID	YEAR	COUNTRY	Subindicator Macroeconomic Vulnerability Indicator	Subindicator Solvency Vulnerability Indicator	Subindicator Market Vulnerability Indicator	Subindicator Liquidity Vulnerability Indicator	Subindicator Social Development Vulnerability Indicator	Subindicator Crisis Latente	MSF GLOBAL INDEX	MSF Binary K-means
48	1988	BOLIVIA	0.17	2.04	0.91	-1.83	1.34	-0.88	0.25	0
49	1989	BOLIVIA	-0.11	1.52	0.57	-1.43	1.26	-0.88	-0.05	0
50	1990	BOLIVIA	-0.03	1.52	0.29	-0.91	1.13	-0.88	-0.20	0
51	1991	BOLIVIA	0.1	1.29	0.1	-0.3	1.33	-0.88	-0.31	0
52	1992	BOLIVIA	0.32	1.27	0.12	-0.1	1.34	-0.71	-0.12	0
53	1993	BOLIVIA	-0.1	1.17	-0.08	1.02	0.95	-0.88	-0.77	0
54	1994	BOLIVIA	-0.04	1.29	-0.2	1.47	1.41	-0.71	-0.57	0
55	1995	BOLIVIA	-0.21	1.2	-0.89	1.29	1.28	-0.88	-0.88	0
56	1996	BOLIVIA	-0.2	1.01	-1.04	1.71	1.39	-0.88	-0.99	0
57	1997	BOLIVIA	-0.34	0.89	-1.22	2.13	0.84	-0.88	-1.28	0
58	1998	BOLIVIA	-0.4	0.48	-1.4	2.23	0.91	-0.88	-1.39	0
59	1999	BOLIVIA	0.38	0.6	-1.14	2.33	1.41	-0.71	-0.86	0
60	2000	BOLIVIA	0.27	0.37	-1.09	2.11	1.65	-0.71	-0.82	0
61	2001	BOLIVIA	0.31	0.4	-0.91	1.94	1.5	-0.71	-0.78	0
62	2002	BOLIVIA	0.26	0.49	-0.82	1.88	1.63	-0.71	-0.73	0
63	2003	BOLIVIA	0.35	0.54	-0.8	1.74	1.6	-0.71	-0.67	0
64	2004	BOLIVIA	-0.16	0.33	-0.86	1.75	0.77	-0.71	-1.04	0
65	2005	BOLIVIA	-0.79	0.32	-0.96	1.87	1.11	-0.88	-1.34	0
66	2006	BOLIVIA	-0.54	-0.75	-0.63	1.67	1.04	-0.88	-1.36	0
67	2007	BOLIVIA	-0.76	-1.7	-0.57	2.07	1.07	-0.88	-1.63	0
68	2008	BOLIVIA	-0.65	-1.91	-0.43	2.14	0.29	-0.88	-1.79	0
69	2009	BOLIVIA	-0.2	-1.76	-0.55	2.66	0.31	-0.71	-1.59	0
70	2010	BOLIVIA	-0.31	-1.74	-0.7	2.3	0.65	-0.71	-1.49	0
71	2011	BOLIVIA	-0.65	-1.74	-0.69	2.35	-0.13	-0.88	-1.93	0
72	2012	BOLIVIA	-1.09	-1.6	-0.81	2.72	-0.49	-0.88	-2.20	0
73	2013	BOLIVIA	-0.97	-1.53	-0.9	2.84	0.37	-0.88	-2.01	0
74	2014	BOLIVIA	-0.98	-1.69	-1.01	3.08	0.29	-0.88	-2.12	0
75	1978	BRASIL	1.13	-0.6	-1.14	-1.38	1.08	-0.71	-0.11	0
76	1979	BRASIL	1.19	-0.61	-1.11	-1.2	1.05	-0.71	-0.14	0
77	1980	BRASIL	1.25	-0.6	-0.83	-2.18	1.01	-0.71	0.12	0
78	1981	BRASIL	1.6	-0.37	-0.82	-2.46	0.98	-0.71	0.30	0
79	1982	BRASIL	1.61	-0.29	-0.54	-2.77	0.93	1.10	2.21	1
80	1983	BRASIL	1.62	-0.18	-0.44	-2.7	0.9	1.10	2.22	1
81	1984	BRASIL	1.08	-0.28	-0.99	-2.54	0.87	-0.71	0.15	0
82	1985	BRASIL	0.93	-0.51	-0.86	-2.41	0.84	-0.71	0.05	0
83	1986	BRASIL	0.96	-0.51	-0.97	-1.43	0.74	-0.71	-0.18	0
84	1987	BRASIL	1.78	0.55	-0.74	-1.07	0.78	1.10	1.95	1
85	1988	BRASIL	2.39	0.52	-0.25	-0.29	0.77	1.10	2.00	1
86	1989	BRASIL	2.06	0.3	-0.57	1.26	0.7	0.31	0.71	1
87	1990	BRASIL	2.85	0.3	-0.73	-0.47	0.71	0.31	1.28	1
88	1991	BRASIL	2.24	0.36	-0.56	-0.01	0.67	1.10	1.82	1
89	1992	BRASIL	2.91	0.43	-0.31	0.41	0.66	1.10	1.95	1
90	1993	BRASIL	2.61	0.2	-0.44	0.98	0.55	1.10	1.67	1
91	1994	BRASIL	1.41	-0.49	-0.47	0.17	0.45	0.31	0.61	1
92	1995	BRASIL	0.69	-0.6	-0.38	-0.08	0.58	0.31	0.50	1
93	1996	BRASIL	0.65	-0.22	-0.11	0.2	0.53	0.31	0.51	1
94	1997	BRASIL	0.42	-0.14	-0.11	0.38	0.46	0.31	0.40	1
95	1998	BRASIL	0.5	-0.18	-0.1	0.15	0.37	0.31	0.45	1
96	1999	BRASIL	0.47	0.38	-0.17	0.22	0.45	0.31	0.52	1
97	2000	BRASIL	-0.11	0.21	-0.21	0.67	0.31	-0.71	-0.81	0
98	2001	BRASIL	0.1	0.23	-0.14	0.5	0.26	-0.71	-0.72	0
99	2002	BRASIL	0.1	0.33	-0.1	0.52	0.21	-0.71	-0.71	0

Table A.5.4. MSF global index

ID	YEAR	COUNTRY	Subindicator Macroeconomic Vulnerability Indicator	Subindicator Solvency Vulnerability Indicator	Subindicator Market Vulnerability Indicator	Subindicator Liquidity Vulnerability Indicator	Subindicator Social Development Vulnerability Indicator	Subindicator Crisis Latence	MSF GLOBAL INDEX	MSF Binary K-means
100	2003	BRASIL	0.46	0.4	-0.07	0.49	0.27	-0.71	-0.58	0
101	2004	BRASIL	-0.25	0.32	-0.14	1.14	0.18	-0.71	-0.95	0
102	2005	BRASIL	0.11	0.66	-0.21	1.14	-0.26	-0.71	-0.90	0
103	2006	BRASIL	-0.13	0.77	-0.38	1.47	-0.24	-0.71	-1.04	0
104	2007	BRASIL	-0.31	-0.5	-0.59	2.22	-0.23	-0.88	-1.64	0
105	2008	BRASIL	-0.26	-0.56	-0.76	2.35	-0.36	-0.88	-1.71	0
106	2009	BRASIL	0.47	-0.18	-0.17	1.49	-0.44	-0.71	-1.04	0
107	2010	BRASIL	-0.11	-0.48	-0.3	1.7	-0.51	-0.88	-1.49	0
108	2011	BRASIL	-0.28	-0.5	-0.29	1.93	-0.18	-0.88	-1.52	0
109	2012	BRASIL	0.1	-0.17	-0.18	2.04	-0.15	-0.88	-1.38	0
110	2013	BRASIL	-0.15	0.11	-0.19	1.73	-0.15	-0.88	-1.33	0
111	2014	BRASIL	0.4	0.22	0.11	1.28	-0.17	1.10	0.94	1
112	1978	CHILE	0.65	0.44	-0.02	-1.07	0.58	-0.88	-0.29	0
113	1979	CHILE	0.45	0.27	-0.35	-0.52	0.42	-0.88	-0.57	0
114	1980	CHILE	0.23	0.05	-0.72	0.17	0.33	-0.88	-0.87	0
115	1981	CHILE	0.41	0.3	-0.69	0.15	0.31	1.10	1.19	1
116	1982	CHILE	0.9	0.51	-0.68	0.74	0.3	1.10	1.23	1
117	1983	CHILE	0.45	0.65	-0.66	0.72	0.22	1.10	1.12	1
118	1984	CHILE	0.12	1.02	-0.85	1.51	0.17	1.10	0.88	1
119	1985	CHILE	0.18	1.21	-0.5	1.62	0.15	1.10	0.94	1
120	1986	CHILE	0.25	1.25	-0.73	1.59	0.15	0.31	0.16	1
121	1987	CHILE	0.06	1.15	-0.82	1.31	0.21	0.31	0.15	0
122	1988	CHILE	-0.09	0.93	-1	1.18	0.11	-0.88	-1.13	0
123	1989	CHILE	-0.45	0.68	-0.87	1.18	0.08	-0.88	-1.25	0
124	1990	CHILE	0.03	0.6	-0.73	1.14	0.08	-0.71	-0.93	0
125	1991	CHILE	-0.09	0.65	-0.65	0.91	0.06	-0.88	-1.08	0
126	1992	CHILE	-0.42	0.58	-0.72	1.13	-0.12	-0.88	-1.27	0
127	1993	CHILE	-0.21	0.51	-0.88	1.06	-0.18	-0.88	-1.24	0
128	1994	CHILE	-0.04	0.43	-0.85	1.13	-0.24	-0.88	-1.23	0
129	1995	CHILE	-0.6	0.29	-0.9	1.11	-0.32	-0.88	-1.42	0
130	1996	CHILE	-0.7	0.2	-1.05	1.56	-0.39	-0.88	-1.59	0
131	1997	CHILE	-0.85	0.21	-1.21	1.78	-0.44	-0.88	-1.71	0
132	1998	CHILE	-0.38	0.11	-1.24	1.97	-0.5	-0.88	-1.65	0
133	1999	CHILE	0.3	0.21	-1.25	1.84	-0.51	-0.71	-1.25	0
134	2000	CHILE	-0.15	0.13	-1.45	1.89	-0.39	-0.88	-1.57	0
135	2001	CHILE	0.11	0.1	-1.33	1.96	-0.36	-0.71	-1.33	0
136	2002	CHILE	0.28	0.1	-1.18	1.94	-0.41	-0.71	-1.27	0
137	2003	CHILE	0.14	0.16	-1	1.75	-0.48	-0.71	-1.25	0
138	2004	CHILE	-0.76	-1	-1.76	2.22	-0.51	-0.88	-2.04	0
139	2005	CHILE	-0.75	-1.48	-1.75	2.42	-0.42	-0.88	-2.13	0
140	2006	CHILE	-0.51	-1.82	-1.74	2.33	-1.44	-0.88	-2.31	0
141	2007	CHILE	-0.97	-1.96	-1.85	2.71	-1.51	-0.88	-2.56	0
142	2008	CHILE	-0.53	-1.72	-1.71	3.11	-1.63	-0.88	-2.50	0
143	2009	CHILE	-0.31	-1.38	-2.18	2.76	-1.59	-0.71	-2.19	0
144	2010	CHILE	-0.38	-1.23	-2.11	2.62	-1.65	-0.88	-2.34	0
145	2011	CHILE	-0.65	-1.04	-2.12	2.56	-1.66	-0.88	-2.37	0
146	2012	CHILE	-0.54	-0.86	-2.16	2.67	-1.91	-0.88	-2.40	0
147	2013	CHILE	-0.45	-0.79	-2.19	2.78	-1.77	-0.88	-2.36	0
148	2014	CHILE	-0.28	-0.64	-2.08	2.54	-1.83	-0.88	-2.24	0
149	1978	COLOMBIA	0.09	-1.72	-0.17	-0.14	1.12	-0.71	-0.69	0
150	1979	COLOMBIA	0.38	-1.68	-0.1	-0.29	1.16	-0.71	-0.56	0
151	1980	COLOMBIA	0.44	-1.23	-0.07	-0.08	1.24	-0.71	-0.50	0

Table A.5.4. MSF global index

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152	1981	COLOMBIA	0.64	-0.9	-0.08	-0.07	0.95	-0.71	-0.46	0
153	1982	COLOMBIA	0.75	-0.91	-0.04	-0.07	0.94	0.31	0.58	1
154	1983	COLOMBIA	0.56	-0.95	-0.27	0.34	0.64	-0.88	-0.84	0
155	1984	COLOMBIA	0.2	-0.74	-0.6	0.24	0.75	-0.88	-0.91	0
156	1985	COLOMBIA	0.49	0.11	-0.12	0.29	0.74	0.31	0.53	1
157	1986	COLOMBIA	0.35	0.17	-0.24	-0.12	0.38	-0.88	-0.69	0
158	1987	COLOMBIA	0.3	0.41	0.04	-0.47	0.29	-0.71	-0.40	0
159	1988	COLOMBIA	0.44	0.19	0.23	-0.87	0.24	-0.71	-0.29	0
160	1989	COLOMBIA	0.54	0.21	0.2	-0.46	0.59	-0.71	-0.28	0
161	1990	COLOMBIA	0.35	0.1	-0.08	-0.26	0.11	-0.71	-0.53	0
162	1991	COLOMBIA	0.41	0.11	-0.11	-0.33	0.05	-0.71	-0.51	0
163	1992	COLOMBIA	0.26	-0.03	-0.21	-0.06	0.05	-0.71	-0.64	0
164	1993	COLOMBIA	0.47	-0.33	-0.42	0.15	0.1	-0.88	-0.87	0
165	1994	COLOMBIA	0.15	-0.76	-0.29	-0.04	0.1	-0.88	-0.96	0
166	1995	COLOMBIA	0.28	-0.68	-0.31	0.26	0.13	-0.88	-0.98	0
167	1996	COLOMBIA	0.59	-0.5	-0.28	0.18	0.14	-0.88	-0.84	0
168	1997	COLOMBIA	0.24	-0.58	-0.43	0.43	0.24	-0.88	-1.00	0
169	1998	COLOMBIA	0.62	-0.24	-0.41	0.13	0.35	0.31	0.44	1
170	1999	COLOMBIA	0.98	-0.08	0.36	-0.23	0.47	0.31	0.76	1
171	2000	COLOMBIA	0.4	-0.11	0.42	-0.7	0.49	0.31	0.71	1
172	2001	COLOMBIA	0.84	0.11	0.41	-0.47	0.4	0.31	0.78	1
173	2002	COLOMBIA	0.8	0.2	0.55	-0.55	0.26	0.31	0.79	1
174	2003	COLOMBIA	0.23	0.1	0.11	-0.76	-0.15	-0.71	-0.48	0
175	2004	COLOMBIA	-0.23	-0.34	-0.04	-0.57	-0.47	-0.88	-0.98	0
176	2005	COLOMBIA	-0.2	-0.59	-0.13	-0.21	-0.53	-0.88	-1.10	0
177	2006	COLOMBIA	-0.48	-1.11	-0.36	-0.04	-0.25	-0.88	-1.26	0
178	2007	COLOMBIA	-0.52	-1.26	-0.52	0.18	-0.42	-0.88	-1.40	0
179	2008	COLOMBIA	-0.26	-1.27	-0.48	0.13	-0.47	-0.88	-1.33	0
180	2009	COLOMBIA	0.01	-1.11	-0.59	0.23	-0.71	-0.71	-1.14	0
181	2010	COLOMBIA	-0.06	-1.06	-0.3	0.2	-0.7	-0.71	-1.10	0
182	2011	COLOMBIA	-0.42	-1.3	-0.71	0.56	-0.83	-0.88	-1.57	0
183	2012	COLOMBIA	-0.05	-1.05	-0.73	0.87	-0.95	-0.88	-1.53	0
184	2013	COLOMBIA	-0.66	-1.37	-0.88	1.04	-0.99	-0.88	-1.80	0
185	2014	COLOMBIA	-0.6	-1.23	-1	1.17	-1.01	-0.88	-1.82	0
186	1978	ECUADOR	-0.42	-0.87	0.99	-1.61	1.22	-0.88	-0.40	0
187	1979	ECUADOR	0.14	-1.01	0.95	-1.73	1.19	-0.71	-0.07	0
188	1980	ECUADOR	0.22	-1.07	1	-1.72	1.17	-0.71	-0.06	0
189	1981	ECUADOR	0.11	-0.86	0.98	-1.84	1.12	-0.88	-0.23	0
190	1982	ECUADOR	0.38	-0.76	0.92	-1.44	1.03	0.31	0.94	1
191	1983	ECUADOR	0.62	-0.06	0.64	-1.2	1.06	0.31	1.03	1
192	1984	ECUADOR	0.51	0.15	0.47	-0.99	1.08	0.31	0.97	1
193	1985	ECUADOR	0.15	0.13	0.71	-1.44	0.91	0.31	0.96	1
194	1986	ECUADOR	0.08	0.76	0.89	-1.01	0.85	0.31	0.95	1
195	1987	ECUADOR	0.29	1.24	1.01	-1.45	1.17	0.31	1.25	1
196	1988	ECUADOR	-0.31	1.46	1.62	-2.04	1.16	-0.71	0.31	0
197	1989	ECUADOR	-0.07	1.43	1.84	-2.95	1.12	-0.71	0.58	1
198	1990	ECUADOR	-0.54	1.4	1.82	-2.55	1.09	-0.71	0.36	0
199	1991	ECUADOR	-0.76	1.15	1.86	-2.41	1.05	-0.71	0.23	0
200	1992	ECUADOR	-0.58	0.94	1.75	-2.4	1	-0.71	0.22	0
201	1993	ECUADOR	0.32	1.17	1.01	-1.82	0.96	-0.71	0.27	0
202	1994	ECUADOR	0.09	0.92	0.51	-1.13	0.95	-0.71	-0.04	0
203	1995	ECUADOR	0.39	0.56	0.39	-0.82	0.88	0.31	0.91	1

Table A.5.4. MSF global index

ID	YEAR	COUNTRY	Subindicator Macroeconomic Vulnerability Indicator	Subindicator Solvency Vulnerability Indicator	Subindicator Market Vulnerability Indicator	Subindicator Liquidity Vulnerability Indicator	Subindicator Social Development Vulnerability Indicator	Subindicator Crisis Latence	MSF GLOBAL INDEX	MSF Binary K-means
204	1996	ECUADOR	0.47	0.54	0.39	-0.73	1	0.31	0.93	1
205	1997	ECUADOR	0.15	0.47	0.26	-0.57	0.96	-0.71	-0.24	0
206	1998	ECUADOR	0.31	0.49	0.41	-0.52	0.74	0.31	0.78	1
207	1999	ECUADOR	0.49	1.21	0.31	-0.85	0.89	0.31	1.02	1
208	2000	ECUADOR	0.3	1.32	0.3	-0.81	0.99	0.31	1.00	1
209	2001	ECUADOR	0.23	0.87	0.18	-1.27	0.59	-0.71	-0.10	0
210	2002	ECUADOR	0.11	0.5	0.29	-1.45	0.65	-0.71	-0.12	0
211	2003	ECUADOR	0.28	0.47	0.81	-1.4	0.5	-0.71	-0.06	0
212	2004	ECUADOR	-0.7	0.26	0.57	-0.86	0.45	-0.88	-0.68	0
213	2005	ECUADOR	-0.58	0.06	0.43	-0.61	0.41	-0.88	-0.76	0
214	2006	ECUADOR	-0.56	-0.27	0.4	-0.58	0.32	-0.88	-0.83	0
215	2007	ECUADOR	-0.2	-0.51	0.33	-0.32	0.7	-0.71	-0.58	0
216	2008	ECUADOR	-0.47	-1.06	0.31	-0.26	0.6	-0.71	-0.77	0
217	2009	ECUADOR	0.15	-1.38	0.36	0.13	0.58	-0.71	-0.73	0
218	2010	ECUADOR	-0.15	-1.23	0.2	-0.07	0.03	-0.71	-0.88	0
219	2011	ECUADOR	-0.93	-1.26	0.16	0.26	-0.05	-0.88	-1.36	0
220	2012	ECUADOR	-0.8	-1.28	0.12	0.33	-0.06	-0.88	-1.35	0
221	2013	ECUADOR	-1.08	-1.03	0.09	0.6	0.16	-0.88	-1.41	0
222	2014	ECUADOR	-0.47	-1.12	0.4	0.26	0.12	-0.71	-0.97	0
223	1978	PARAGUAY	-0.87	-0.58	0.38	-0.24	1.12	-0.88	-0.87	0
224	1979	PARAGUAY	-0.5	-0.82	1.1	-0.52	1.1	-0.88	-0.73	0
225	1980	PARAGUAY	-0.58	-1.05	0.49	-0.45	1.07	-0.88	-0.81	0
226	1981	PARAGUAY	-0.55	-1.31	0.64	-0.64	1.07	-0.88	-0.78	0
227	1982	PARAGUAY	0.2	-0.93	0.6	-0.49	1.03	0.31	0.62	1
228	1983	PARAGUAY	0.37	-0.81	0.69	-0.65	0.99	0.31	0.73	1
229	1984	PARAGUAY	0.16	-0.04	0.87	-1.07	0.95	0.31	0.89	1
230	1985	PARAGUAY	-0.23	1.08	1.16	-1.48	1.05	-0.71	0.07	0
231	1986	PARAGUAY	-0.12	1.11	1.23	-1.67	0.88	-0.71	0.12	0
232	1987	PARAGUAY	-0.2	1.46	1.58	-2.01	0.83	-0.71	0.26	0
233	1988	PARAGUAY	-0.26	0.96	1.34	-1.99	0.79	-0.71	0.13	0
234	1989	PARAGUAY	-0.09	0.99	1.46	-1.87	0.75	0.31	1.17	1
235	1990	PARAGUAY	0.1	0.43	1.22	-1.58	0.87	-0.71	0.06	0
236	1991	PARAGUAY	0.28	0.44	1.16	-1.33	0.99	-0.71	0.07	0
237	1992	PARAGUAY	0.4	0.35	0.94	-1.01	0.96	0.31	1.00	1
238	1993	PARAGUAY	-0.05	-0.25	0.34	-0.08	0.89	-0.71	-0.51	0
239	1994	PARAGUAY	-0.06	-0.63	0.21	0.41	0.75	-0.71	-0.72	0
240	1995	PARAGUAY	-0.11	0.11	0.53	-0.11	0.63	0.31	0.52	1
241	1996	PARAGUAY	-0.52	-0.67	0.24	-0.18	0.51	-0.71	-0.77	0
242	1997	PARAGUAY	-1.12	-0.87	-0.3	0.22	0.51	-0.88	-1.29	0
243	1998	PARAGUAY	-0.62	-0.49	0.15	-0.33	0.39	-0.88	-0.95	0
244	1999	PARAGUAY	-0.18	-0.08	0.03	-0.17	0.34	-0.88	-0.83	0
245	2000	PARAGUAY	0.24	-0.05	0.11	-0.37	0.57	0.31	0.58	1
246	2001	PARAGUAY	0.39	-0.05	0.14	0.06	0.49	0.31	0.52	1
247	2002	PARAGUAY	0.37	0.31	0.2	-0.4	0.53	0.31	0.68	1
248	2003	PARAGUAY	-0.4	0.24	1.03	-1.15	0.4	-0.71	-0.32	0
249	2004	PARAGUAY	-0.64	-0.3	1.04	-1.04	0.32	-0.71	-0.50	0
250	2005	PARAGUAY	-0.34	-0.28	1	-0.96	0.28	-0.71	-0.45	0
251	2006	PARAGUAY	-0.87	-0.58	1.05	-1	0.28	-0.88	-0.80	0
252	2007	PARAGUAY	-0.76	-0.87	0.75	-0.66	0.22	-0.88	-0.93	0
253	2008	PARAGUAY	-0.63	-1.42	0.2	-0.14	0.17	-0.88	-1.17	0
254	2009	PARAGUAY	0.21	-1.23	0.15	0.53	0.25	-0.71	-0.87	0
255	2010	PARAGUAY	-1.1	-1.52	-0.33	1.13	0.11	-0.88	-1.66	0

Table A.5.4. MSF global index

ID	YEAR	COUNTRY	Subindicator Macroeconomic Vulnerability Indicator	Subindicator Solvency Vulnerability Indicator	Subindicator Market Vulnerability Indicator	Subindicator Liquidity Vulnerability Indicator	Subindicator Social Development Vulnerability Indicator	Subindicator Crisis Latente	MSF GLOBAL INDEX	MSF Binary K-means
256	2011	PARAGUAY	-0.62	-2.78	-0.52	1.31	-0.1	-0.71	-1.65	0
257	2012	PARAGUAY	-0.11	-1.3	-0.65	1.66	-0.1	-0.71	-1.38	0
258	2013	PARAGUAY	-1.53	-2.77	-0.77	1.95	-0.08	-0.88	-2.23	0
259	2014	PARAGUAY	-1.24	-1.88	-0.94	2.1	-0.22	-0.88	-2.11	0
260	1978	PERÚ	0.8	1.04	1.45	-2.31	1.33	1.10	2.42	1
261	1979	PERÚ	0.65	0.27	1.7	-2.39	1.31	-0.71	0.51	1
262	1980	PERÚ	0.62	-0.08	1.2	-1.75	1.29	-0.71	0.25	0
263	1981	PERÚ	0.73	0.27	1.21	-1.98	1.33	0.31	1.40	1
264	1982	PERÚ	1	0.43	1.09	-1.71	1.25	0.31	1.41	1
265	1983	PERÚ	1.24	0.72	0.88	-1.44	1.22	1.10	2.21	1
266	1984	PERÚ	0.6	0.77	0.5	-1.21	1.19	-0.71	0.14	0
267	1985	PERÚ	0.77	1.04	0.89	-1.56	1.18	-0.71	0.35	0
268	1986	PERÚ	0.84	1.25	1.19	-2	1.1	-0.88	0.33	0
269	1987	PERÚ	0.85	0.82	1.11	-2.2	1.05	-0.88	0.30	0
270	1988	PERÚ	2.11	1.48	1.19	-2.57	1.02	1.10	2.79	1
271	1989	PERÚ	2.34	0.67	1.37	-3.56	0.96	1.10	2.96	1
272	1990	PERÚ	2.53	0.85	1.47	-3.48	0.92	1.10	3.02	1
273	1991	PERÚ	1.01	0.34	1.97	-3.61	0.89	0.31	1.84	1
274	1992	PERÚ	1.12	0.21	1.69	-2.75	0.89	0.31	1.63	1
275	1993	PERÚ	0.74	0.42	1.49	-2.27	0.69	-0.71	0.38	1
276	1994	PERÚ	0.43	0.29	1.26	-1.93	0.72	-0.71	0.18	0
277	1995	PERÚ	0.11	0.21	0.99	-1.53	0.73	-0.88	-0.22	0
278	1996	PERÚ	0.07	0.05	0.53	-0.8	0.89	-0.88	-0.43	0
279	1997	PERÚ	-0.23	0.1	0.27	-0.24	-0.13	-0.88	-0.87	0
280	1998	PERÚ	0.07	0.21	0.1	0.2	0.81	-0.88	-0.70	0
281	1999	PERÚ	-0.05	0.46	0.11	0.1	0.85	-0.88	-0.66	0
282	2000	PERÚ	-0.11	0.51	0.3	-0.17	0.53	-0.88	-0.65	0
283	2001	PERÚ	0.11	0.41	0.32	-0.01	0.62	-0.88	-0.62	0
284	2002	PERÚ	-0.46	0.47	0.25	0.57	0.38	-0.88	-0.95	0
285	2003	PERÚ	-0.25	0.12	0.43	0.1	0.11	-0.88	-0.88	0
286	2004	PERÚ	-0.21	-0.06	0.64	-0.34	-0.27	-0.88	-0.85	0
287	2005	PERÚ	-0.5	-0.17	0.54	0	-0.17	-0.88	-1.01	0
288	2006	PERÚ	-0.66	-0.28	0.72	-0.25	-0.42	-0.88	-1.05	0
289	2007	PERÚ	-0.94	-0.81	0.4	0.42	-0.49	-0.88	-1.40	0
290	2008	PERÚ	-1.29	-0.84	0.11	0.98	-0.83	-0.88	-1.73	0
291	2009	PERÚ	-0.41	-0.73	0.21	0.84	-0.91	-0.88	-1.45	0
292	2010	PERÚ	-0.66	-1.02	0.13	0.74	-1.04	-0.88	-1.57	0
293	2011	PERÚ	-0.39	-1.54	0.05	0.85	-1	-0.88	-1.60	0
294	2012	PERÚ	-0.7	-1.7	-0.02	0.94	-1.05	-0.88	-1.75	0
295	2013	PERÚ	-0.7	-1.9	-0.21	1.26	-1.09	-0.88	-1.88	0
296	2014	PERÚ	-0.26	-1.84	-0.34	1.35	-1.09	-0.88	-1.78	0
297	1978	URUGUAY	0.62	1.11	-0.24	0.33	0.73	-0.71	-0.33	0
298	1979	URUGUAY	0.93	0.9	-0.46	0.27	0.71	-0.71	-0.29	0
299	1980	URUGUAY	0.8	0.85	-0.56	0.53	0.6	-0.71	-0.42	0
300	1981	URUGUAY	0.52	0.85	-0.68	0.88	0.47	0.31	0.40	1
301	1982	URUGUAY	0.95	1.29	-0.43	1.14	0.39	0.31	0.54	1
302	1983	URUGUAY	0.69	1.78	-0.25	1.27	0.34	0.31	0.52	1
303	1984	URUGUAY	0.66	2.09	-0.59	1.24	0.29	0.31	0.51	1
304	1985	URUGUAY	0.44	2.06	-0.45	1.12	0.28	0.31	0.49	1
305	1986	URUGUAY	0.39	2.02	-0.5	1.11	0.18	-0.71	-0.57	0
306	1987	URUGUAY	0.42	1.95	-0.61	0.86	0.2	-0.71	-0.53	0
307	1988	URUGUAY	0.65	1.83	-0.65	0.81	0.17	-0.71	-0.48	0

Table A.5.4. MSF global index

ID	YEAR	COUNTRY	Subindicator Macroeconomic Vulnerability Indicator	Subindicator Solvency Vulnerability Indicator	Subindicator Market Vulnerability Indicator	Subindicator Liquidity Vulnerability Indicator	Subindicator Social Development Vulnerability Indicator	Subindicator Crisis Latente	MSF GLOBAL INDEX	MSF Binary K-means
308	1989	URUGUAY	0.85	1.62	-0.55	0.69	0.11	-0.71	-0.44	0
309	1990	URUGUAY	0.98	1.42	0.13	0.09	0.11	0.31	0.80	1
310	1991	URUGUAY	0.67	1.38	0.34	-0.18	0.1	0.79	0.31	1
311	1992	URUGUAY	0.34	1.47	0.16	0.28	0.09	-0.71	-0.42	0
312	1993	URUGUAY	0.67	1.51	0.22	0.08	0.1	-0.71	-0.28	0
313	1994	URUGUAY	0.25	1.51	0.22	-0.05	0.08	-0.71	-0.36	0
314	1995	URUGUAY	0.77	1.43	0.16	0.07	0.02	-0.71	-0.28	0
315	1996	URUGUAY	0.28	1.41	0.13	0.16	-0.04	-0.71	-0.45	0
316	1997	URUGUAY	0.31	1.51	0.31	0.08	-0.62	-0.71	-0.52	0
317	1998	URUGUAY	0.06	1.63	-0.18	0.79	-0.03	-0.88	-0.83	0
318	1999	URUGUAY	0.38	1.36	-0.06	0.85	-0.03	-0.88	-0.78	0
319	2000	URUGUAY	0.79	1.38	0.21	0.8	-0.04	-0.71	-0.45	0
320	2001	URUGUAY	0.84	1.36	0.21	0.99	-0.05	-0.71	-0.48	0
321	2002	URUGUAY	1.38	1.65	0.31	1.08	-0.07	0.31	0.61	1
322	2003	URUGUAY	0.79	1.52	0.31	0.61	-0.18	0.31	0.61	1
323	2004	URUGUAY	0.27	1.64	0.21	0.08	-0.1	0.31	0.61	1
324	2005	URUGUAY	0.22	1.43	0.27	0.45	-0.18	0.31	0.48	1
325	2006	URUGUAY	-0.34	0.87	0.27	0.4	0.37	-0.88	-0.82	0
326	2007	URUGUAY	-0.48	0.75	0.33	0.7	-0.59	-0.88	-1.14	0
327	2008	URUGUAY	-0.6	0.51	0.09	1.11	-0.54	-0.88	-1.31	0
328	2009	URUGUAY	-0.74	0.65	0.61	0.61	-0.62	-0.88	-1.17	0
329	2010	URUGUAY	-0.77	0.37	0.51	0.56	-0.62	-0.88	-1.22	0
330	2011	URUGUAY	-0.48	0.13	0.48	0.81	-0.68	-0.88	-1.25	0
331	2012	URUGUAY	-0.24	0.13	0.48	0.82	-0.71	-0.88	-1.19	0
332	2013	URUGUAY	-0.39	0.11	0.34	0.97	-0.75	-0.88	-1.29	0
333	2014	URUGUAY	-0.27	0.28	0.25	1.05	-0.63	-0.88	-1.24	0
334	1978	VENEZUELA	-0.34	-1.34	-0.99	1.68	0.55	-0.88	-1.54	0
335	1979	VENEZUELA	0.05	-0.9	-0.88	1.28	0.5	-0.88	-1.28	0
336	1980	VENEZUELA	0.27	-0.98	-0.88	1.11	0.55	-0.88	-1.19	0
337	1981	VENEZUELA	0.44	-0.5	-0.66	1.04	0.64	-0.88	-1.01	0
338	1982	VENEZUELA	0.85	0.31	0.1	1.04	0.54	0.31	0.49	1
339	1983	VENEZUELA	0.95	0.27	-0.08	0.8	0.56	0.31	0.54	1
340	1984	VENEZUELA	0.81	0.2	0.18	0.81	0.44	0.31	0.50	1
341	1985	VENEZUELA	0.61	0.11	-0.5	1.37	0.49	-0.88	-0.96	0
342	1986	VENEZUELA	-0.13	0.19	-0.36	1.17	0.51	-0.88	-1.19	0
343	1987	VENEZUELA	1.1	0.85	-0.41	1.17	0.4	-0.71	-0.51	0
344	1988	VENEZUELA	0.22	0.63	-0.5	0.91	0.34	-0.71	-0.74	0
345	1989	VENEZUELA	0.91	0.88	-0.2	0.02	0.26	1.10	1.49	1
346	1990	VENEZUELA	0.14	0.67	-0.08	0.05	0.37	-0.71	-0.51	0
347	1991	VENEZUELA	0.15	0.52	-0.03	0.47	0.3	-0.71	-0.63	0
348	1992	VENEZUELA	0.21	0.47	0.01	0.14	0.09	-0.71	-0.59	0
349	1993	VENEZUELA	0.3	0.41	0.32	-0.35	0.25	-0.71	-0.40	0
350	1994	VENEZUELA	0.66	0.34	1.3	-1.01	0.07	1.10	1.72	1
351	1995	VENEZUELA	0.5	-0.11	1.53	-1.23	0.12	1.10	1.70	1
352	1996	VENEZUELA	0.85	0.06	1.88	-2.23	0.42	1.10	2.13	1
353	1997	VENEZUELA	0.26	-0.08	1.24	-1.63	0.46	1.10	1.75	1
354	1998	VENEZUELA	0.57	-0.11	1.3	-1.75	0.39	1.10	1.85	1
355	1999	VENEZUELA	0.63	-0.06	1.48	-1.89	0.49	1.10	1.95	1
356	2000	VENEZUELA	0.16	-0.87	1.65	-1.96	0.6	-0.88	-0.21	0
357	2001	VENEZUELA	-0.37	-0.71	1.72	-1.84	0.59	-0.88	-0.35	0
358	2002	VENEZUELA	0.46	0.1	1.94	-2.4	0.65	1.27	2.30	1
359	2003	VENEZUELA	0.41	0.22	2.16	-2.01	0.66	1.10	2.08	1

Table A.5.4. MSF global index

ID	YEAR	COUNTRY	Subindicator Macroeconomic Vulnerability Indicator	Subindicator Solvency Vulnerability Indicator	Subindicator Market Vulnerability Indicator	Subindicator Liquidity Vulnerability Indicator	Subindicator Social Development Vulnerability Indicator	Subindicator Crisis Latente	MSF GLOBAL INDEX	MSF Binary K-means
360	2004	VENEZUELA	0,02	-0,65	1,79	-1,77	0,5	1,27	1,89	1
361	2005	VENEZUELA	-0,1	-1,05	1,48	-1,48	0,44	-0,88	-0,47	0
362	2006	VENEZUELA	-0,33	-1,1	1,02	-0,53	-0,88	-0,88	-1,08	0
363	2007	VENEZUELA	-0,37	-1,8	0,47	-0,01	0,39	-0,88	-1,10	0
364	2008	VENEZUELA	-0,13	-1,6	0,68	-0,39	0,37	-0,88	-0,91	0
365	2009	VENEZUELA	0,4	-1,91	0,56	-0,27	0,45	0,31	0,36	0
366	2010	VENEZUELA	0,53	-2,19	0,9	-0,64	0,53	1,10	1,28	1
367	2011	VENEZUELA	0,11	-1,4	0,54	-0,14	0,53	-0,71	-0,67	0
368	2012	VENEZUELA	0,02	-0,7	0,21	0,14	0,42	-0,71	-0,72	0
369	2013	VENEZUELA	0,47	-0,26	0,1	0,02	0,52	0,31	0,52	1
370	2014	VENEZUELA	0,84	-0,28	-0,11	-0,13	0,52	1,27	1,58	1

APPENDIX

Table A.5.5. Uncertainty Levels

ID	YEAR	COUNTRY	MSF Zscore	MSF Binary Discriminant	MSF Binary KNN	MSF Binary SVM	Uncertainty level - Discriminant	Uncertainty level - KNN	Uncertainty level - SVM
1	1978	ARGENTINA	1.62	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
2	1979	ARGENTINA	1.59	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
3	1980	ARGENTINA	1.71	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
4	1981	ARGENTINA	1.77	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
5	1982	ARGENTINA	1.95	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
6	1983	ARGENTINA	1.92	1	1	1	UNMANAGEABLE	UNMANAGEABLE	INTOLERABLE
7	1984	ARGENTINA	2.10	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
8	1985	ARGENTINA	2.32	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
9	1986	ARGENTINA	1.93	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
10	1987	ARGENTINA	2.06	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
11	1988	ARGENTINA	1.97	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
12	1989	ARGENTINA	2.24	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
13	1990	ARGENTINA	2.71	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
14	1991	ARGENTINA	2.28	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
15	1992	ARGENTINA	0.06	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
16	1993	ARGENTINA	-0.72	0	0	0	STABLE	STABLE	STABLE
17	1994	ARGENTINA	-0.49	0	0	0	MODERATE	MODERATE	MODERATE
18	1995	ARGENTINA	1.61	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
19	1996	ARGENTINA	-0.57	0	0	0	STABLE	STABLE	STABLE
20	1997	ARGENTINA	-0.65	0	0	0	STABLE	STABLE	STABLE
21	1998	ARGENTINA	-0.78	0	0	0	STABLE	STABLE	STABLE
22	1999	ARGENTINA	1.06	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
23	2000	ARGENTINA	0.99	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
24	2001	ARGENTINA	1.87	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
25	2002	ARGENTINA	2.39	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
26	2003	ARGENTINA	1.83	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
27	2004	ARGENTINA	-0.16	0	0	0	MODERATE	MODERATE	MODERATE
28	2005	ARGENTINA	-0.33	0	0	0	MODERATE	MODERATE	MODERATE
29	2006	ARGENTINA	-0.36	0	0	0	MODERATE	MODERATE	MODERATE
30	2007	ARGENTINA	-0.41	0	0	0	MODERATE	MODERATE	MODERATE
31	2008	ARGENTINA	-0.31	0	0	0	MODERATE	MODERATE	MODERATE
32	2009	ARGENTINA	0.53	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
33	2010	ARGENTINA	-0.54	0	0	0	MODERATE	MODERATE	MODERATE
34	2011	ARGENTINA	-0.50	0	0	0	MODERATE	MODERATE	MODERATE
35	2012	ARGENTINA	-0.46	0	0	0	MODERATE	MODERATE	MODERATE
36	2013	ARGENTINA	-0.44	0	0	0	MODERATE	MODERATE	MODERATE
37	2014	ARGENTINA	1.55	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
38	1978	BOLIVIA	0.23	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
39	1979	BOLIVIA	1.10	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
40	1980	BOLIVIA	1.12	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
41	1981	BOLIVIA	1.11	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
42	1982	BOLIVIA	1.84	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
43	1983	BOLIVIA	2.22	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
44	1984	BOLIVIA	2.60	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
45	1985	BOLIVIA	3.06	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
46	1986	BOLIVIA	2.76	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
47	1987	BOLIVIA	0.41	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
48	1988	BOLIVIA	0.30	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE

Table A.5.5. Uncertainty Levels

ID	YEAR	COUNTRY	MSF Zscore	MSF Binary Discriminant	MSF Binary KNN	MSF Binary SVM	Uncertainty level - Discriminant	Uncertainty level - KNN	Uncertainty level - SVM
49	1989	BOLIVIA	0.07	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
50	1990	BOLIVIA	-0.05	0	0	0	MANAGEABLE	MODERATE	MANAGEABLE
51	1991	BOLIVIA	-0.14	0	0	0	MODERATE	MODERATE	MODERATE
52	1992	BOLIVIA	0.02	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
53	1993	BOLIVIA	-0.50	0	0	0	MODERATE	MODERATE	MODERATE
54	1994	BOLIVIA	-0.34	0	0	0	MODERATE	MODERATE	MODERATE
55	1995	BOLIVIA	-0.59	0	0	0	STABLE	STABLE	STABLE
56	1996	BOLIVIA	-0.67	0	0	0	STABLE	STABLE	STABLE
57	1997	BOLIVIA	-0.90	0	0	0	STABLE	STABLE	STABLE
58	1998	BOLIVIA	-0.98	0	0	0	STABLE	STABLE	STABLE
59	1999	BOLIVIA	-0.57	0	0	0	MODERATE	MODERATE	MODERATE
60	2000	BOLIVIA	-0.54	0	0	0	MODERATE	MODERATE	MODERATE
61	2001	BOLIVIA	-0.50	0	0	0	MODERATE	MODERATE	MODERATE
62	2002	BOLIVIA	-0.47	0	0	0	MODERATE	MODERATE	MODERATE
63	2003	BOLIVIA	-0.42	0	0	0	MODERATE	MODERATE	MODERATE
64	2004	BOLIVIA	-0.70	0	0	0	STABLE	STABLE	STABLE
65	2005	BOLIVIA	-0.94	0	0	0	STABLE	STABLE	STABLE
66	2006	BOLIVIA	-0.96	0	0	0	STABLE	STABLE	STABLE
67	2007	BOLIVIA	-1.17	0	0	0	STRONG	STRONG	STRONG
68	2008	BOLIVIA	-1.30	0	0	0	STRONG	STRONG	STRONG
69	2009	BOLIVIA	-1.14	0	0	0	STRONG	STRONG	STRONG
70	2010	BOLIVIA	-1.06	0	0	0	STABLE	STABLE	STRONG
71	2011	BOLIVIA	-1.41	0	0	0	STRONG	STRONG	STRONG
72	2012	BOLIVIA	-1.62	0	0	0	STRONG	STRONG	STRONG
73	2013	BOLIVIA	-1.47	0	0	0	STRONG	STRONG	STRONG
74	2014	BOLIVIA	-1.56	0	0	0	STRONG	STRONG	STRONG
75	1978	BRASIL	0.02	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
76	1979	BRASIL	0.00	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
77	1980	BRASIL	0.20	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
78	1981	BRASIL	0.34	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
79	1982	BRASIL	1.84	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
80	1983	BRASIL	1.85	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
81	1984	BRASIL	0.22	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
82	1985	BRASIL	0.15	0	0	0	MANAGEABLE	MODERATE	MANAGEABLE
83	1986	BRASIL	-0.04	0	0	0	MANAGEABLE	MODERATE	MANAGEABLE
84	1987	BRASIL	1.64	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
85	1988	BRASIL	1.68	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
86	1989	BRASIL	0.67	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
87	1990	BRASIL	1.11	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
88	1991	BRASIL	1.54	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
89	1992	BRASIL	1.64	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
90	1993	BRASIL	1.42	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
91	1994	BRASIL	0.59	1	1	1	MANAGEABLE	MANAGEABLE	MANAGEABLE
92	1995	BRASIL	0.50	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
93	1996	BRASIL	0.51	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
94	1997	BRASIL	0.43	1	1	1	MANAGEABLE	MANAGEABLE	MANAGEABLE
95	1998	BRASIL	0.46	1	1	1	MANAGEABLE	MANAGEABLE	MANAGEABLE
96	1999	BRASIL	0.52	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
97	2000	BRASIL	-0.53	0	0	0	MODERATE	MODERATE	MODERATE
98	2001	BRASIL	-0.45	0	0	0	MODERATE	MODERATE	MODERATE
99	2002	BRASIL	-0.45	0	0	0	MODERATE	MODERATE	MODERATE
100	2003	BRASIL	-0.35	0	0	0	MODERATE	MODERATE	MODERATE
101	2004	BRASIL	-0.64	0	0	0	STABLE	STABLE	STABLE

Table A.5.5. Uncertainty Levels

ID	YEAR	COUNTRY	MSF Zscore	MSF Binary Discriminant	MSF Binary KNN	MSF Binary SVM	Uncertainty level - Discriminant	Uncertainty level - KNN	Uncertainty level - SVM
102	2005	BRASIL	-0.60	0	0	0	STABLE	STABLE	STABLE
103	2006	BRASIL	-0.71	0	0	0	STABLE	STABLE	STABLE
104	2007	BRASIL	-1.18	0	0	0	STRONG	STRONG	STRONG
105	2008	BRASIL	-1.23	0	0	0	STRONG	STRONG	STRONG
106	2009	BRASIL	-0.71	0	0	0	STABLE	STABLE	STABLE
107	2010	BRASIL	-1.06	0	0	0	STABLE	STABLE	STABLE
108	2011	BRASIL	-1.09	0	0	0	STABLE	STABLE	STABLE
109	2012	BRASIL	-0.97	0	0	0	STABLE	STABLE	STABLE
110	2013	BRASIL	-0.94	0	0	0	STABLE	STABLE	STABLE
111	2014	BRASIL	0.84	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
112	1978	CHILE	-0.12	0	0	0	MODERATE	MODERATE	MODERATE
113	1979	CHILE	-0.34	0	0	0	MODERATE	MODERATE	MODERATE
114	1980	CHILE	-0.58	0	0	0	STABLE	STABLE	STABLE
115	1981	CHILE	1.05	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
116	1982	CHILE	1.07	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
117	1983	CHILE	0.99	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
118	1984	CHILE	0.80	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
119	1985	CHILE	0.85	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
120	1986	CHILE	0.23	1	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
121	1987	CHILE	0.23	1	1	1	MANAGEABLE	MANAGEABLE	MANAGEABLE
122	1988	CHILE	-0.78	0	0	0	STABLE	STABLE	STABLE
123	1989	CHILE	-0.87	0	0	0	STABLE	STABLE	STABLE
124	1990	CHILE	-0.62	0	0	0	STABLE	STABLE	STABLE
125	1991	CHILE	-0.74	0	0	0	STABLE	STABLE	STABLE
126	1992	CHILE	-0.89	0	0	0	STABLE	STABLE	STABLE
127	1993	CHILE	-0.87	0	0	0	STABLE	STABLE	STABLE
128	1994	CHILE	-0.86	0	0	0	STABLE	STABLE	STABLE
129	1995	CHILE	-1.01	0	0	0	STABLE	STABLE	STABLE
130	1996	CHILE	-1.14	0	0	0	STRONG	STRONG	STRONG
131	1997	CHILE	-1.23	0	0	0	STRONG	STRONG	STRONG
132	1998	CHILE	-1.19	0	0	0	STRONG	STRONG	STRONG
133	1999	CHILE	-0.87	0	0	0	STABLE	STABLE	STABLE
134	2000	CHILE	-1.13	0	0	0	STRONG	STRONG	STRONG
135	2001	CHILE	-0.93	0	0	0	STABLE	STABLE	STABLE
136	2002	CHILE	-0.89	0	0	0	STABLE	STABLE	STABLE
137	2003	CHILE	-0.87	0	0	0	STABLE	STABLE	STABLE
138	2004	CHILE	-1.49	0	0	0	STRONG	STRONG	STRONG
139	2005	CHILE	-1.56	0	0	0	STRONG	STRONG	STRONG
140	2006	CHILE	-1.70	0	0	0	STRONG	STRONG	STRONG
141	2007	CHILE	-1.90	0	0	0	STRONG	STRONG	STRONG
142	2008	CHILE	-1.85	0	0	0	STRONG	STRONG	STRONG
143	2009	CHILE	-1.61	0	0	0	STRONG	STRONG	STRONG
144	2010	CHILE	-1.73	0	0	0	STRONG	STRONG	STRONG
145	2011	CHILE	-1.76	0	0	0	STRONG	STRONG	STRONG
146	2012	CHILE	-1.77	0	0	0	STRONG	STRONG	STRONG
147	2013	CHILE	-1.75	0	0	0	STRONG	STRONG	STRONG
148	2014	CHILE	-1.65	0	0	0	STRONG	STRONG	STRONG
149	1978	COLOMBIA	-0.43	0	0	0	MODERATE	MODERATE	MODERATE
150	1979	COLOMBIA	-0.33	0	0	0	MODERATE	MODERATE	MODERATE
151	1980	COLOMBIA	-0.28	0	0	0	MODERATE	MODERATE	MODERATE
152	1981	COLOMBIA	-0.26	0	0	0	MODERATE	MODERATE	MODERATE
153	1982	COLOMBIA	0.57	1	1	1	MANAGEABLE	MANAGEABLE	MANAGEABLE
154	1983	COLOMBIA	-0.55	0	0	0	STABLE	STABLE	STABLE

Table A.5.5. Uncertainty Levels

ID	YEAR	COUNTRY	MSF Zscore	MSF Binary Discriminant	MSF Binary KNN	MSF Binary SVM	Uncertainty level - Discriminant	Uncertainty level - KNN	Uncertainty level - SVM
155	1984	COLOMBIA	-0.61	0	0	0	STABLE	STABLE	STABLE
156	1985	COLOMBIA	0.53	1	1	1	MANAGEABLE	MANAGEABLE	MANAGEABLE
157	1986	COLOMBIA	-0.43	0	0	0	MODERATE	MODERATE	MODERATE
158	1987	COLOMBIA	-0.20	0	0	0	MODERATE	MODERATE	MODERATE
159	1988	COLOMBIA	-0.12	0	0	0	MODERATE	MODERATE	MODERATE
160	1989	COLOMBIA	-0.12	0	0	0	MODERATE	MODERATE	MODERATE
161	1990	COLOMBIA	-0.31	0	0	0	MODERATE	MODERATE	MODERATE
162	1991	COLOMBIA	-0.29	0	0	0	MODERATE	MODERATE	MODERATE
163	1992	COLOMBIA	-0.40	0	0	0	MODERATE	MODERATE	MODERATE
164	1993	COLOMBIA	-0.57	0	0	0	STABLE	STABLE	STABLE
165	1994	COLOMBIA	-0.65	0	0	0	STABLE	STABLE	STABLE
166	1995	COLOMBIA	-0.66	0	0	0	STABLE	STABLE	STABLE
167	1996	COLOMBIA	-0.55	0	0	0	MODERATE	MODERATE	MODERATE
168	1997	COLOMBIA	-0.68	0	0	0	STABLE	STABLE	STABLE
169	1998	COLOMBIA	0.45	1	1	1	MANAGEABLE	MANAGEABLE	MANAGEABLE
170	1999	COLOMBIA	0.70	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
171	2000	COLOMBIA	0.66	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
172	2001	COLOMBIA	0.72	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
173	2002	COLOMBIA	0.73	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
174	2003	COLOMBIA	-0.27	0	0	0	MODERATE	MODERATE	MODERATE
175	2004	COLOMBIA	-0.66	0	0	0	STABLE	STABLE	STABLE
176	2005	COLOMBIA	-0.76	0	0	0	STABLE	STABLE	STABLE
177	2006	COLOMBIA	-0.88	0	0	0	STABLE	STABLE	STABLE
178	2007	COLOMBIA	-0.99	0	0	0	STABLE	STABLE	STABLE
179	2008	COLOMBIA	-0.93	0	0	0	STABLE	STABLE	STABLE
180	2009	COLOMBIA	-0.78	0	0	0	STABLE	STABLE	STABLE
181	2010	COLOMBIA	-0.76	0	0	0	STABLE	STABLE	STABLE
182	2011	COLOMBIA	-1.12	0	0	0	STRONG	STRONG	STRONG
183	2012	COLOMBIA	-1.09	0	0	0	STRONG	STRONG	STRONG
184	2013	COLOMBIA	-1.31	0	0	0	STRONG	STRONG	STRONG
185	2014	COLOMBIA	-1.32	0	0	0	STRONG	STRONG	STRONG
186	1978	ECUADOR	-0.20	0	0	0	MODERATE	MODERATE	MODERATE
187	1979	ECUADOR	0.05	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
188	1980	ECUADOR	0.06	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
189	1981	ECUADOR	-0.07	0	0	0	MODERATE	MODERATE	MODERATE
190	1982	ECUADOR	0.85	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
191	1983	ECUADOR	0.92	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
192	1984	ECUADOR	0.87	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
193	1985	ECUADOR	0.86	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
194	1986	ECUADOR	0.85	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
195	1987	ECUADOR	1.09	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
196	1988	ECUADOR	0.35	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
197	1989	ECUADOR	0.57	0	0	0	UNSTABLE	UNSTABLE	UNSTABLE
198	1990	ECUADOR	0.39	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
199	1991	ECUADOR	0.29	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
200	1992	ECUADOR	0.28	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
201	1993	ECUADOR	0.32	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
202	1994	ECUADOR	0.07	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
203	1995	ECUADOR	0.82	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
204	1996	ECUADOR	0.84	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
205	1997	ECUADOR	-0.08	0	0	0	MODERATE	MODERATE	MODERATE
206	1998	ECUADOR	0.72	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
207	1999	ECUADOR	0.91	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE

Table A.5.5. Uncertainty Levels

ID	YEAR	COUNTRY	MSF Zscore	MSF Binary Discriminant	MSF Binary KNN	MSF Binary SVM	Uncertainty level - Discriminant	Uncertainty level - KNN	Uncertainty level - SVM
208	2000	ECUADOR	0.90	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
209	2001	ECUADOR	0.03	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
210	2002	ECUADOR	0.01	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
211	2003	ECUADOR	0.06	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
212	2004	ECUADOR	-0.43	0	0	0	MODERATE	MODERATE	MODERATE
213	2005	ECUADOR	-0.49	0	0	0	MODERATE	MODERATE	MODERATE
214	2006	ECUADOR	-0.54	0	0	0	MODERATE	MODERATE	MODERATE
215	2007	ECUADOR	-0.35	0	0	0	MODERATE	MODERATE	MODERATE
216	2008	ECUADOR	-0.49	0	0	0	MODERATE	MODERATE	MODERATE
217	2009	ECUADOR	-0.46	0	0	0	MODERATE	MODERATE	MODERATE
218	2010	ECUADOR	-0.58	0	0	0	STABLE	STABLE	STABLE
219	2011	ECUADOR	-0.96	0	0	0	STABLE	STABLE	STABLE
220	2012	ECUADOR	-0.95	0	0	0	STABLE	STABLE	STABLE
221	2013	ECUADOR	-1.00	0	0	0	STABLE	STABLE	STABLE
222	2014	ECUADOR	-0.66	0	0	0	STABLE	STABLE	STABLE
223	1978	PARAGUAY	-0.57	0	0	0	MODERATE	MODERATE	MODERATE
224	1979	PARAGUAY	-0.47	0	0	0	MODERATE	MODERATE	MODERATE
225	1980	PARAGUAY	-0.53	0	0	0	MODERATE	MODERATE	MODERATE
226	1981	PARAGUAY	-0.50	0	0	0	MODERATE	MODERATE	MODERATE
227	1982	PARAGUAY	0.60	1	1	1	MANAGEABLE	MANAGEABLE	MANAGEABLE
228	1983	PARAGUAY	0.68	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
229	1984	PARAGUAY	0.80	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
230	1985	PARAGUAY	0.17	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
231	1986	PARAGUAY	0.20	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
232	1987	PARAGUAY	0.31	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
233	1988	PARAGUAY	0.21	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
234	1989	PARAGUAY	1.03	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
235	1990	PARAGUAY	0.16	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
236	1991	PARAGUAY	0.16	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
237	1992	PARAGUAY	0.90	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
238	1993	PARAGUAY	-0.29	0	0	0	MODERATE	MODERATE	MODERATE
239	1994	PARAGUAY	-0.46	0	0	0	MODERATE	MODERATE	MODERATE
240	1995	PARAGUAY	0.52	1	1	1	MANAGEABLE	MANAGEABLE	MANAGEABLE
241	1996	PARAGUAY	-0.49	0	0	0	MODERATE	MODERATE	MODERATE
242	1997	PARAGUAY	-0.90	0	0	0	STABLE	STABLE	STABLE
243	1998	PARAGUAY	-0.64	0	0	0	STABLE	STABLE	STABLE
244	1999	PARAGUAY	-0.55	0	0	0	MODERATE	MODERATE	MODERATE
245	2000	PARAGUAY	0.56	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
246	2001	PARAGUAY	0.51	1	1	1	MANAGEABLE	MANAGEABLE	MANAGEABLE
247	2002	PARAGUAY	0.64	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
248	2003	PARAGUAY	-0.14	0	0	0	MODERATE	MODERATE	MODERATE
249	2004	PARAGUAY	-0.28	0	0	0	MODERATE	MODERATE	MODERATE
250	2005	PARAGUAY	-0.24	0	0	0	MODERATE	MODERATE	MODERATE
251	2006	PARAGUAY	-0.52	0	0	0	MODERATE	MODERATE	MODERATE
252	2007	PARAGUAY	-0.63	0	0	0	STABLE	STABLE	STABLE
253	2008	PARAGUAY	-0.81	0	0	0	STABLE	STABLE	STABLE
254	2009	PARAGUAY	-0.58	0	0	0	STABLE	STABLE	STABLE
255	2010	PARAGUAY	-1.20	0	0	0	STRONG	STRONG	STRONG
256	2011	PARAGUAY	-1.18	0	0	0	STRONG	STRONG	STRONG
257	2012	PARAGUAY	-0.98	0	0	0	STABLE	STABLE	STABLE
258	2013	PARAGUAY	-1.64	0	0	0	STRONG	STRONG	STRONG
259	2014	PARAGUAY	-1.55	0	0	0	STRONG	STRONG	STRONG
260	1978	PERU	2.01	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE

Table A.5.5. Uncertainty Levels

ID	YEAR	COUNTRY	MSF Zscore	MSF Binary Discriminant	MSF Binary KNN	MSF Binary SVM	Uncertainty level - Discriminant	Uncertainty level - KNN	Uncertainty level - SVM
261	1979	PERU	0.51	0	0	0	UNSTABLE	UNSTABLE	UNSTABLE
262	1980	PERU	0.30	0	1	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
263	1981	PERU	1.21	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
264	1982	PERU	1.21	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
265	1983	PERU	1.84	1	1	1	UNMANAGEABLE	INTOLERABLE	UNMANAGEABLE
266	1984	PERU	0.22	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
267	1985	PERU	0.38	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
268	1986	PERU	0.37	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
269	1987	PERU	0.34	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
270	1988	PERU	2.30	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
271	1989	PERU	2.43	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
272	1990	PERU	2.48	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
273	1991	PERU	1.55	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
274	1992	PERU	1.39	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
275	1993	PERU	0.40	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
276	1994	PERU	0.25	0	0	0	MANAGEABLE	MANAGEABLE	MANAGEABLE
277	1995	PERU	-0.06	0	0	0	MODERATE	MODERATE	MODERATE
278	1996	PERU	-0.23	0	0	0	MODERATE	MODERATE	MODERATE
279	1997	PERU	-0.58	0	0	0	STABLE	STABLE	STABLE
280	1998	PERU	-0.44	0	0	0	MODERATE	MODERATE	MODERATE
281	1999	PERU	-0.41	0	0	0	MODERATE	MODERATE	MODERATE
282	2000	PERU	-0.41	0	0	0	MODERATE	MODERATE	MODERATE
283	2001	PERU	-0.38	0	0	0	MODERATE	MODERATE	MODERATE
284	2002	PERU	-0.64	0	0	0	STABLE	STABLE	STABLE
285	2003	PERU	-0.58	0	0	0	MODERATE	MODERATE	MODERATE
286	2004	PERU	-0.56	0	0	0	MODERATE	MODERATE	MODERATE
287	2005	PERU	-0.69	0	0	0	STABLE	STABLE	STABLE
288	2006	PERU	-0.71	0	0	0	STABLE	STABLE	STABLE
289	2007	PERU	-0.99	0	0	0	STABLE	STABLE	STABLE
290	2008	PERU	-1.25	0	0	0	STRONG	STRONG	STRONG
291	2009	PERU	-1.03	0	0	0	STABLE	STABLE	STABLE
292	2010	PERU	-1.13	0	0	0	STRONG	STRONG	STRONG
293	2011	PERU	-1.15	0	0	0	STRONG	STRONG	STRONG
294	2012	PERU	-1.26	0	0	0	STRONG	STRONG	STRONG
295	2013	PERU	-1.36	0	0	0	STRONG	STRONG	STRONG
296	2014	PERU	-1.29	0	0	0	STRONG	STRONG	STRONG
297	1978	URUGUAY	-0.15	0	0	0	MODERATE	MODERATE	MODERATE
298	1979	URUGUAY	-0.12	0	0	0	MODERATE	MODERATE	MODERATE
299	1980	URUGUAY	-0.22	0	0	0	MODERATE	MODERATE	MODERATE
300	1981	URUGUAY	0.42	1	1	1	MANAGEABLE	MANAGEABLE	MANAGEABLE
301	1982	URUGUAY	0.53	1	1	1	MANAGEABLE	MANAGEABLE	MANAGEABLE
302	1983	URUGUAY	0.52	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
303	1984	URUGUAY	0.51	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
304	1985	URUGUAY	0.49	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
305	1986	URUGUAY	-0.34	0	0	0	MODERATE	MODERATE	MODERATE
306	1987	URUGUAY	-0.30	0	0	0	MODERATE	MODERATE	MODERATE
307	1988	URUGUAY	-0.27	0	0	0	MODERATE	MODERATE	MODERATE
308	1989	URUGUAY	-0.23	0	0	0	MODERATE	MODERATE	MODERATE
309	1990	URUGUAY	0.74	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
310	1991	URUGUAY	0.73	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
311	1992	URUGUAY	-0.22	0	0	0	MODERATE	MODERATE	MODERATE
312	1993	URUGUAY	-0.11	0	0	0	MODERATE	MODERATE	MODERATE
313	1994	URUGUAY	-0.18	0	0	0	MODERATE	MODERATE	MODERATE

Table A.5.5. Uncertainty Levels

ID	YEAR	COUNTRY	MSF Zscore	MSF Binary Discriminant	MSF Binary KNN	MSF Binary SVM	Uncertainty level - Discriminant	Uncertainty level - KNN	Uncertainty level - SVM
314	1995	URUGUAY	-0.11	0	0	0	MODERATE	MODERATE	MODERATE
315	1996	URUGUAY	-0.24	0	0	0	MODERATE	MODERATE	MODERATE
316	1997	URUGUAY	-0.30	0	0	0	MODERATE	MODERATE	MODERATE
317	1998	URUGUAY	-0.54	0	0	0	MODERATE	MODERATE	MODERATE
318	1999	URUGUAY	-0.50	0	0	0	MODERATE	MODERATE	MODERATE
319	2000	URUGUAY	-0.24	0	0	0	MODERATE	MODERATE	MODERATE
320	2001	URUGUAY	-0.27	0	0	0	MODERATE	MODERATE	MODERATE
321	2002	URUGUAY	0.67	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
322	2003	URUGUAY	0.59	1	1	1	MANAGEABLE	MANAGEABLE	MANAGEABLE
323	2004	URUGUAY	0.59	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
324	2005	URUGUAY	0.48	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
325	2006	URUGUAY	-0.54	0	0	0	MODERATE	MODERATE	MODERATE
326	2007	URUGUAY	-0.78	0	0	0	STABLE	STABLE	STABLE
327	2008	URUGUAY	-0.92	0	0	0	STABLE	STABLE	STABLE
328	2009	URUGUAY	-0.81	0	0	0	STABLE	STABLE	STABLE
329	2010	URUGUAY	-0.85	0	0	0	STABLE	STABLE	STABLE
330	2011	URUGUAY	-0.87	0	0	0	STABLE	STABLE	STABLE
331	2012	URUGUAY	-0.83	0	0	0	STABLE	STABLE	STABLE
332	2013	URUGUAY	-0.91	0	0	0	STABLE	STABLE	STABLE
333	2014	URUGUAY	-0.87	0	0	0	STABLE	STABLE	STABLE
334	1978	VENEZUELA	-1.10	0	0	0	STRONG	STRONG	STRONG
335	1979	VENEZUELA	-0.90	0	0	0	STABLE	STABLE	STABLE
336	1980	VENEZUELA	-0.82	0	0	0	STABLE	STABLE	STABLE
337	1981	VENEZUELA	-0.68	0	0	0	STABLE	STABLE	STABLE
338	1982	VENEZUELA	0.49	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
339	1983	VENEZUELA	0.53	1	1	1	MANAGEABLE	MANAGEABLE	MANAGEABLE
340	1984	VENEZUELA	0.50	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE
341	1985	VENEZUELA	-0.64	0	0	0	STABLE	STABLE	STABLE
342	1986	VENEZUELA	-0.83	0	0	0	STABLE	STABLE	STABLE
343	1987	VENEZUELA	-0.29	0	0	0	MODERATE	MODERATE	MODERATE
344	1988	VENEZUELA	-0.47	0	0	0	MODERATE	MODERATE	MODERATE
345	1989	VENEZUELA	1.28	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
346	1990	VENEZUELA	-0.30	0	0	0	MODERATE	MODERATE	MODERATE
347	1991	VENEZUELA	-0.39	0	0	0	MODERATE	MODERATE	MODERATE
348	1992	VENEZUELA	-0.36	0	0	0	MODERATE	MODERATE	MODERATE
349	1993	VENEZUELA	-0.20	0	0	0	MODERATE	MODERATE	MODERATE
350	1994	VENEZUELA	1.45	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
351	1995	VENEZUELA	1.44	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
352	1996	VENEZUELA	1.78	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
353	1997	VENEZUELA	1.48	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
354	1998	VENEZUELA	1.56	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
355	1999	VENEZUELA	1.64	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
356	2000	VENEZUELA	-0.06	0	0	0	MODERATE	MODERATE	MODERATE
357	2001	VENEZUELA	-0.17	0	0	0	MODERATE	MODERATE	MODERATE
358	2002	VENEZUELA	1.92	1	1	1	UNMANAGEABLE	UNMANAGEABLE	UNMANAGEABLE
359	2003	VENEZUELA	1.74	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
360	2004	VENEZUELA	1.60	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE
361	2005	VENEZUELA	-0.26	0	0	0	MODERATE	MODERATE	MODERATE
362	2006	VENEZUELA	-0.74	0	0	0	STABLE	STABLE	STABLE
363	2007	VENEZUELA	-0.76	0	0	0	STABLE	STABLE	STABLE
364	2008	VENEZUELA	-0.60	0	0	0	STABLE	STABLE	STABLE
365	2009	VENEZUELA	0.39	1	1	1	MANAGEABLE	MANAGEABLE	MANAGEABLE
366	2010	VENEZUELA	1.11	1	1	1	UNSTABLE	UNSTABLE	UNSTABLE

Table A.5.5. Uncertainty Levels

ID	YEAR	COUNTRY	MSF Zscore	MSF Binary Discriminant	MSF Binary KNN	MSF Binary SVM	Uncertainty level - Discriminant	Uncertainty level - KNN	Uncertainty level - SVM
367	2011	VENEZUELA	-0,42	0	0	0	MODERATE	MODERATE	MODERATE
368	2012	VENEZUELA	-0,46	0	0	0	MODERATE	MODERATE	MODERATE
369	2013	VENEZUELA	0,51	1	1	1	MANAGEABLE	MANAGEABLE	MANAGEABLE
370	2014	VENEZUELA	1,35	1	1	1	INTOLERABLE	INTOLERABLE	INTOLERABLE

B. Appendices to chapter 4

B.1. APPENDIX

Table B.1.1. Descriptions and source of the variables

Variables	Definition	Source
Main independents variables		
Trade openness (%of GDP)	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.	World Bank, World Development Indicators (WDI).
Financial openness	The financial openness indicator is composed of the sum of the stock of foreign asset (FA) and foreign liabilities (FL) over GDP.	External Wealth of Nations (EWN) database of IMF updated to 2015 (see Lane and Milesi-Ferretti, "The External Wealth of Nations Mark II", Journal of International Economics, November 2007).
Private financial openness	The index is defined as the sum of countries' private foreign assets and private foreign liabilities divided by GDP. The private foreign assets is composed by the subtraction between the stock of foreign assets (FA) and foreign reserves (FR), while private foreign liabilities is composed by the subtraction between the foreign liabilities (FL) and debt assets (DA).	External Wealth of Nations (EWN) database of IMF updated to 2015.
Control variables		
GDP growth (annual %)	Annual percentage growth rate of GDP at market prices based on constant local currency. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products.	World Bank, World Development Indicators (WDI)
Financial Development	Financial development is composed by sub-indices, which measure: deep, accessible, and efficient financial institutions and financial markets. These sub-indices are aggregated into the overall measure of financial development (FD).	Svirydzenka K., "Introducing a New Broad-based Index of Financial Development". International Monetary Fund IMF, Working paper WP/16/5 (2016).

Table B.1.1. Descriptions and source of the variables

Variables	Definition	Source
Terms of trade volatility	The standard deviation of the log difference of the terms of trade. Net barter terms of trade index is calculated as the percentage ratio of the export unit value indexes to the import unit value indexes, measured relative to the base year 2000.	World Bank, World Development Indicators (WDI).
Official exchange rate volatility (LCU per USD)	The standard deviation of the log difference of the official exchange rate. Official exchange rate is calculated as an annual average based on monthly averages (local currency units relative to the U.S. dollar).	World Bank, World Development Indicators (WDI).
Banking crisis dummy	Dummy variable for the presence of banking crisis (1=banking crisis, 0=none).	International Monetary Fund, Systemic banking crises data base. Leaven and Valencia 2012, IMF working paper 12/163
Manufactures exports (%of merchandise exports)	Manufactures comprise commodities in SITC sections 5 (chemicals), 6 (basic manufactures), 7 (machinery and transport equipment), and 8 (miscellaneous manufactured goods), excluding division 68 (non-ferrous metals).	World Bank, World Development Indicators (WDI).
TB1YR (1-Year Treasury Bill)	Yield on 1-Year Treasury Bill.	Federal Reserve Bank USA, FRED economic data
Control variables for robustness models		
Trade balance (%of GDP)	Trade balance is the calculation of a country's exports %of GDP minus its imports %of GDP.	World Bank, World Development Indicators (WDI).
Domestic credit to private sector (%of GDP)	Domestic credit to private sector refers to financial resources provided to the private sector by financial corporations, such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment.	World Bank, World Development Indicators (WDI)
High-technology exports (%of manufactured exports)	High-technology exports are products with high RD intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.	World Bank, World Development Indicators (WDI)
Oil price	Annual average of domestic oil nominal price (in USA/Barrel).	Bureau of Labor Statistics of United States and Federal Reserve Bank USA, FRED economic data.

Table B.1.2. Results of Fixed model

Dependent variable = MSF	(1) Fixed Model
Trade Openness	-0.57*** (0.108)
Financial Openness	0.07 (0.062)
GDP growth (annual%)	-0.091*** (0.010)
Financial Development	-0.607*** (0.061)
Official Exchange Rate Volatility	0.173*** (0.061)
Terms of trade Volatility	1.085** (0.412)
Banking crisis dummy	1.025*** (0.117)
Manufactures exports	-0.020*** (0.006)
TB1YR (1-Year Treasury Bill)	0.012 (0.028)
R-squared	0.62
# obs	370

Note: Robust standard errors are in parenthesis.

***: significant at the 1% level, **: significant at the 5% level,

*: significant at the 10% level.

Note: Variables in first difference : trade balance.

Table B.1.3. Hausman test results

Model	Spatial model (Wec)		Spatial model (Wtp)		Spatial model (Wta)	
	Chi square	df	Chi square	df	Chi square	df
Model 1	25.36	9	2953.1	9	82.97	9
Model 2	36.91	9	57.33	9	3078.8	9
Robustness model 1	12.25	7	20.83	7	124.04	7
Robustness model 2	49.67	6	106.63	6	50.13	6

Source: Authors' calculation

Table B.1.4. The LM test for SAR models

LM Test results for spatial dependence		Wec		Wtp		Wta	
Spatial autocorrelation model (SAR)		Test		t-stat		t-stat	
Model 1	Lagrange multiplier test	t-stat	p value	t-stat	p value	t-stat	p value
Model 2	Lagrange multiplier test	13.79	0.000	12.07	0.000	7.12	0.007
Robustness model 1	Lagrange multiplier test	12.65	0.000	11.01	0.000	6.52	0.010
Robustness model 2	Lagrange multiplier test	10.13	0.001	5.74	0.016	5.32	0.021
	Lagrange multiplier test	5.74	0.016	2.08	0.048	2.58	0.041

Source: Authors' calculation

C. Appendices to chapter 5

C.1. APPENDIX

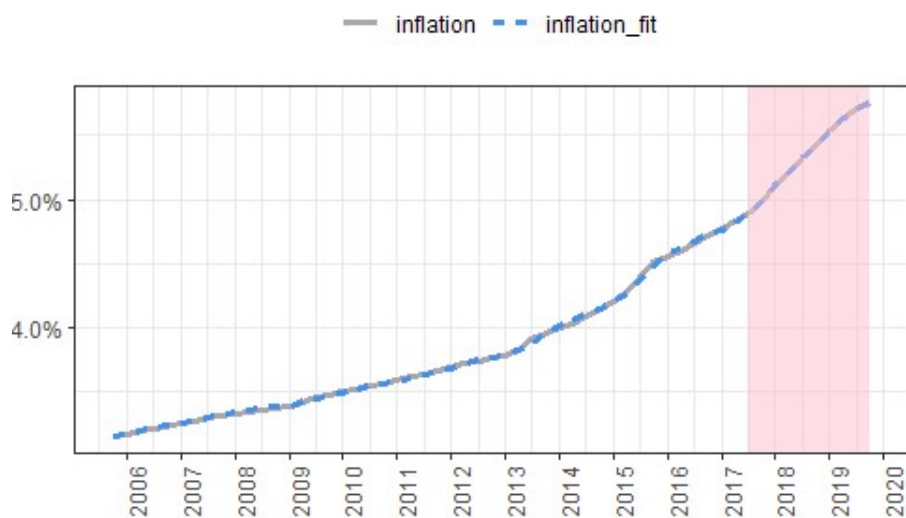
Table C.1.1. Definition of Variables and Data Sources

Variable	Definition	Source
Liquid assets to Short term liabilities (%)	The liquidity ratios are a result of dividing cash and other liquid assets by the short term borrowings and current liabilities. They show the number of times the short term debt obligations are covered by the cash and liquid assets. If the value is greater than 1, it means the short term obligations are fully covered	International Monetary Fund and Central Bank of each country
Bank Liquid Reserves to Bank Assets (%)	Ratio of bank liquid reserves to bank assets is the ratio of domestic currency holdings and deposits with the monetary authorities to claims on other governments, nonfinancial public enterprises, the private sector, and other banking institutions.	International Monetary Fund and Central Bank of each country
GDP growth	Quarter percentage growth rate of GDP at market prices based on constant local currency.	International Monetary Fund and Central Bank of each country
Inflation	Inflation measured by consumer price index (CPI) is defined as the change in the prices of a basket of goods and services that are typically purchased by specific groups of households. Inflation as measured by the quarter growth rate .	ECLAC: Economic Commission for Latin America and the Caribbean
Nominal Real Exchange rate	The nominal exchange rate is the amount of domestic currency needed to purchase foreign currency. In economics, the NEER is an indicator of a country's international competitiveness in terms of the foreign exchange market	International Monetary Fund and Central Bank of each country
Real Interest rate	Real interest rate is the lending interest rate adjusted for inflation as measured by the GDP deflator. The terms and conditions attached to lending rates differ by country, however, limiting their comparability.	International Monetary Fund and Central Bank of each country

Figure C.1.1. Threshold variable: Inflation

Argentina, threshold variable: Inflation

Threshold value: 4.89412394949793%

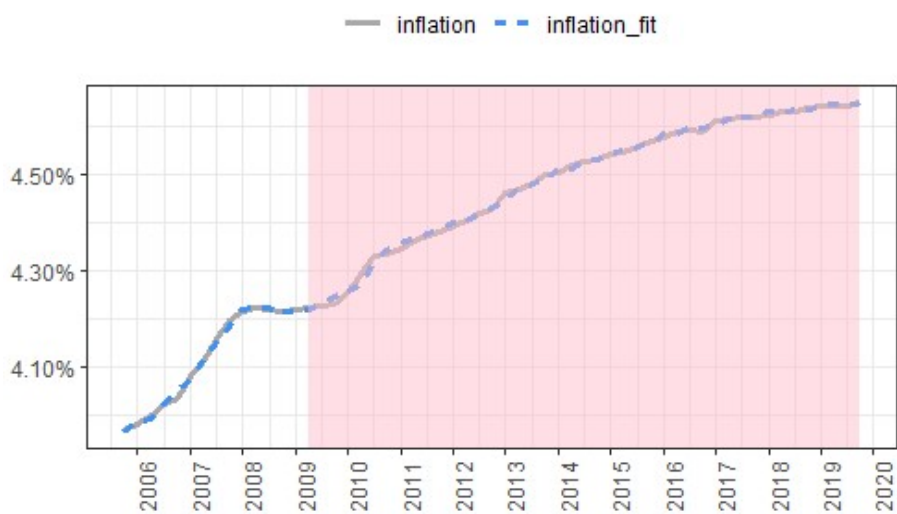


In the graph, the shaded section corresponds to the periods of high regime.

(a) Argentina - Threshold value=4,89%

Bolivia, threshold variable: Inflation

Threshold value: 4.22467418882647%

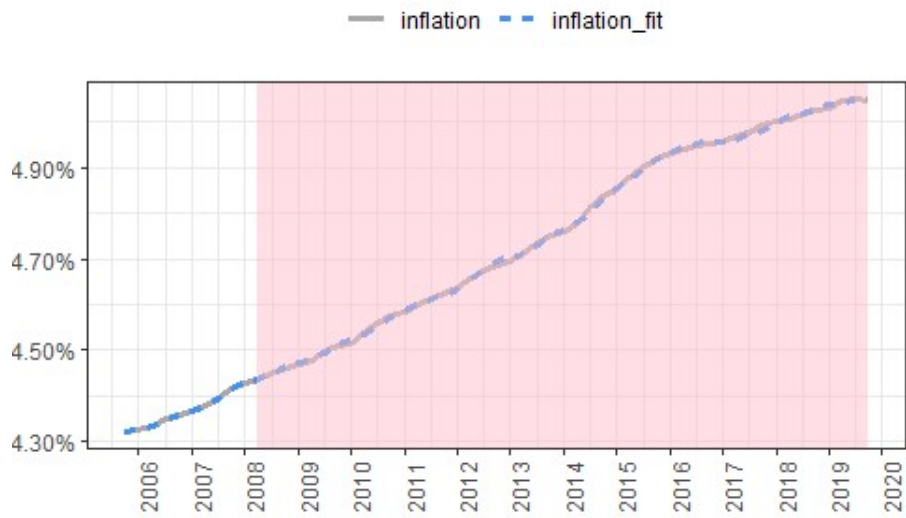


In the graph, the shaded section corresponds to the periods of high regime.

(b) Bolivia Threshold value=4,22%

Brasil, threshold variable: Inflation

Threshold value: 4.43695459066888%

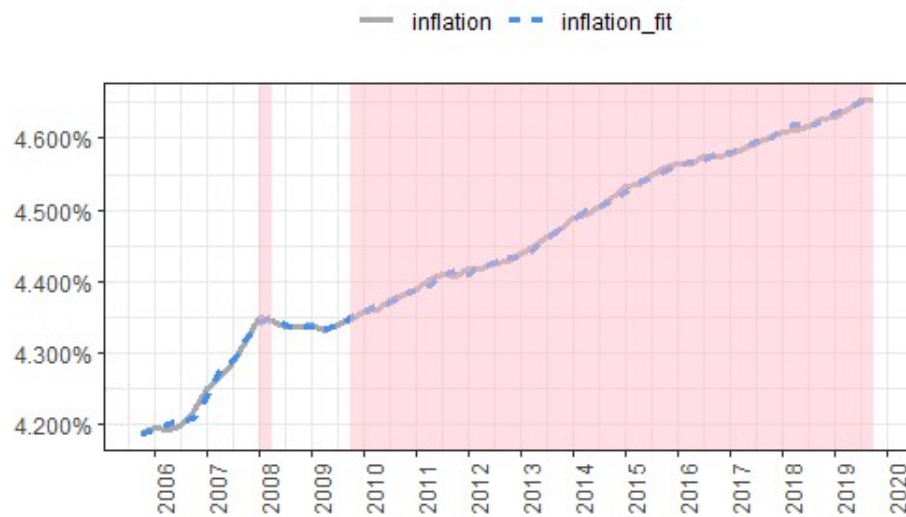


In the graph, the shaded section corresponds to the periods of high regime.

(a) Brazil-Threshold value=4,43%

Chile, threshold variable: Inflation

Threshold value: 4.339495%

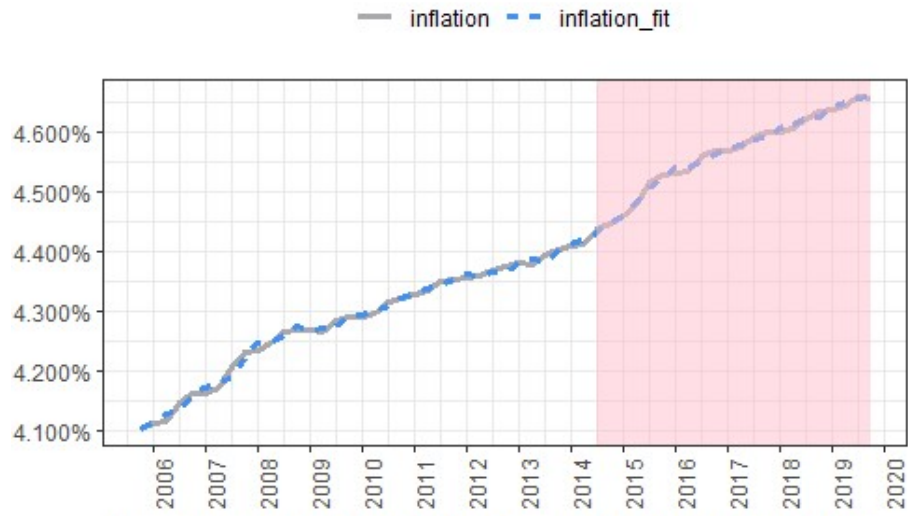


In the graph, the shaded section corresponds to the periods of high regime.

(b) Chile-Threshold value=4,33%

Colombia, threshold variable: Inflation

Threshold value: 4.412435%

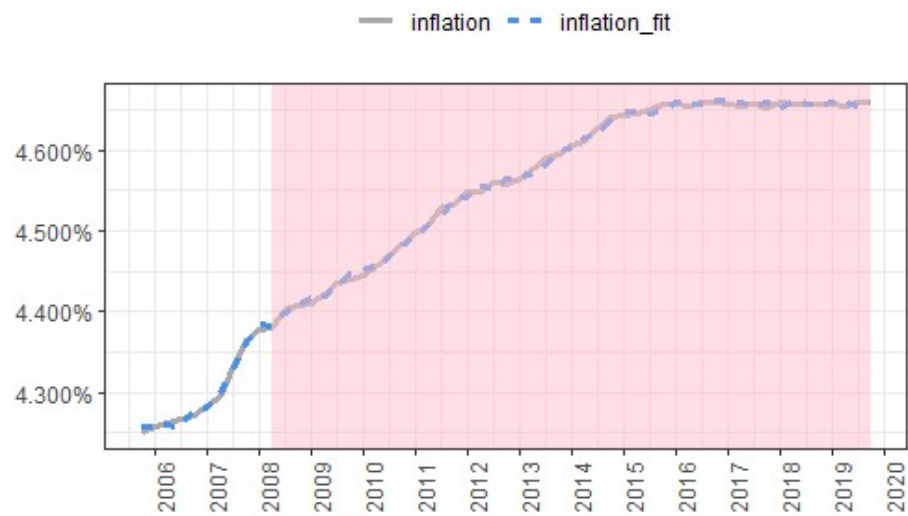


In the graph, the shaded section corresponds to the periods of high regime.

(a) Colombia-Threshold value=4,41%

Ecuador, threshold variable: Inflation

Threshold value: 4.3804967149433%

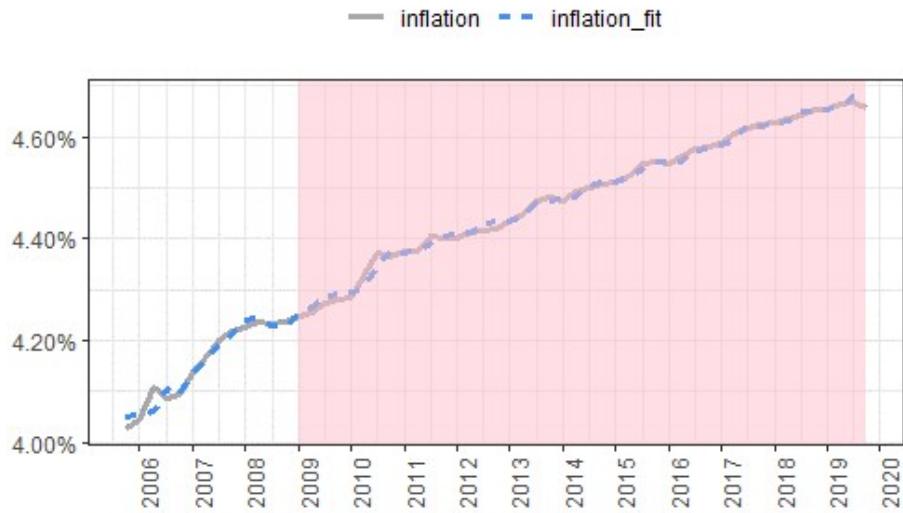


In the graph, the shaded section corresponds to the periods of high regime.

(b) Ecuador-Threshold value=4,38%

Paraguay, threshold variable: Inflation

Threshold value: 4.23858919592989%

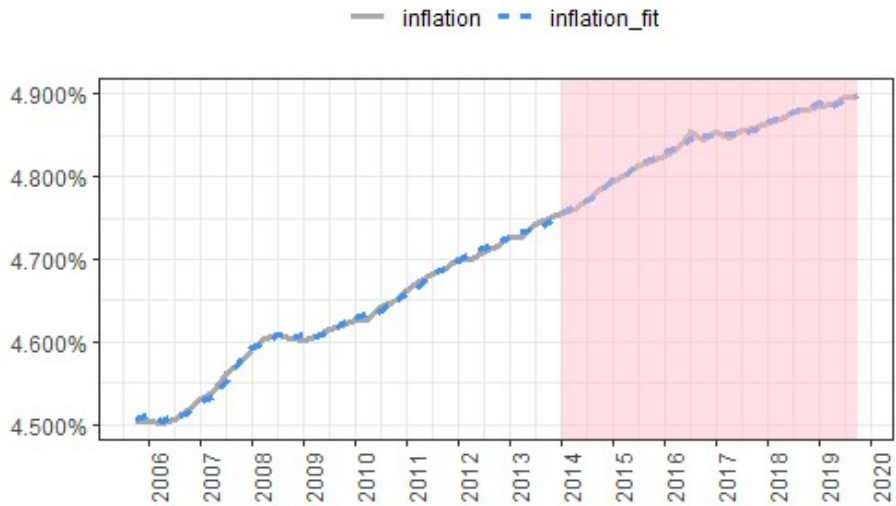


In the graph, the shaded section corresponds to the periods of high regime.

(a) Paraguay-Threshold value=4,23%

Perú, threshold variable: Inflation

Threshold value: 4.754538%

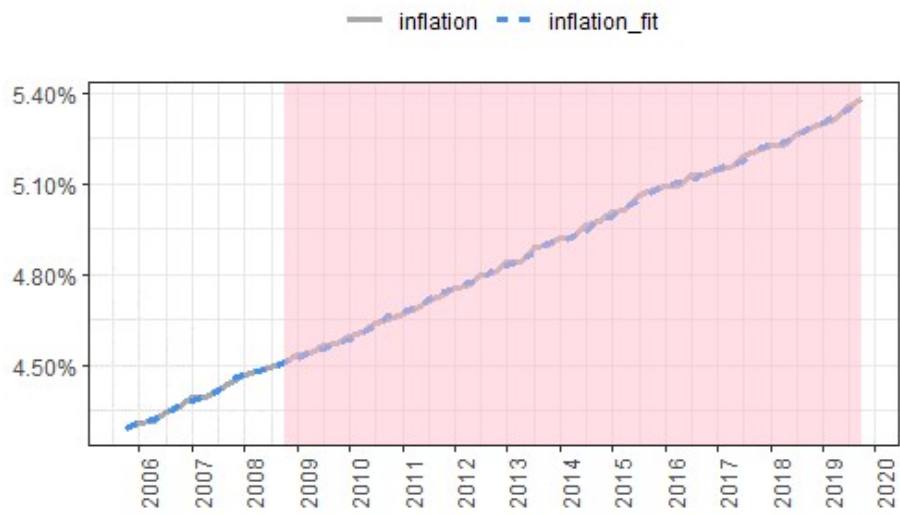


In the graph, the shaded section corresponds to the periods of high regime.

(b) Peru-Threshold value=4,75%

Uruguay, threshold variable: Inflation

Threshold value: 4.508604%



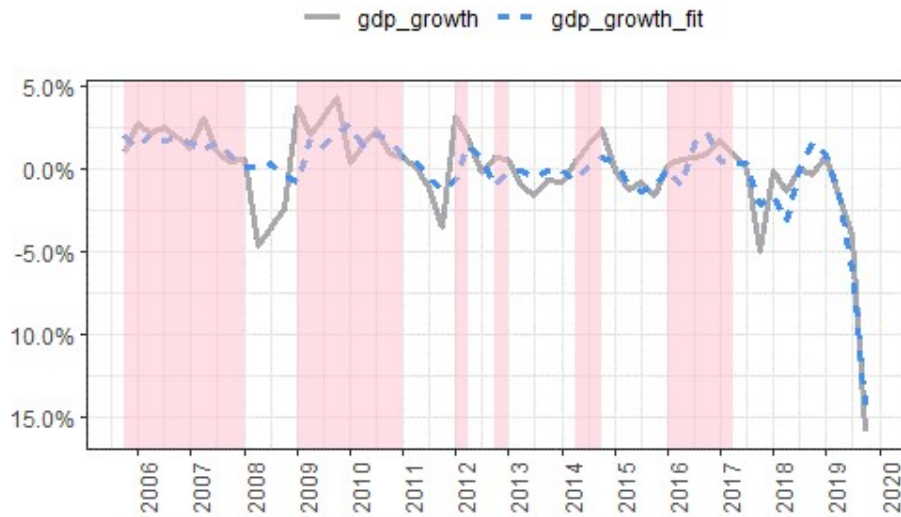
In the graph, the shaded section corresponds to the periods of high regime.

(a) Uruguay-Threshold value=4,50%

Figure C.1.3. Threshold variable: GDP Growth

Argentina, threshold variable: GDP growth

Threshold value: 0.3%

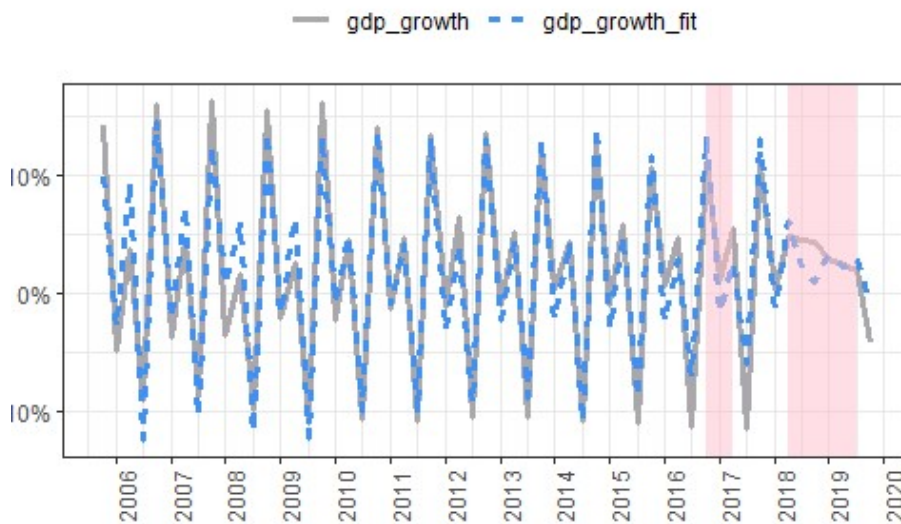


In the graph, the shaded section corresponds to the periods of high regime.

(a) Argentina - Threshold value = 0,3%

Bolivia, threshold variable: GDP growth

Threshold value: 1.11%

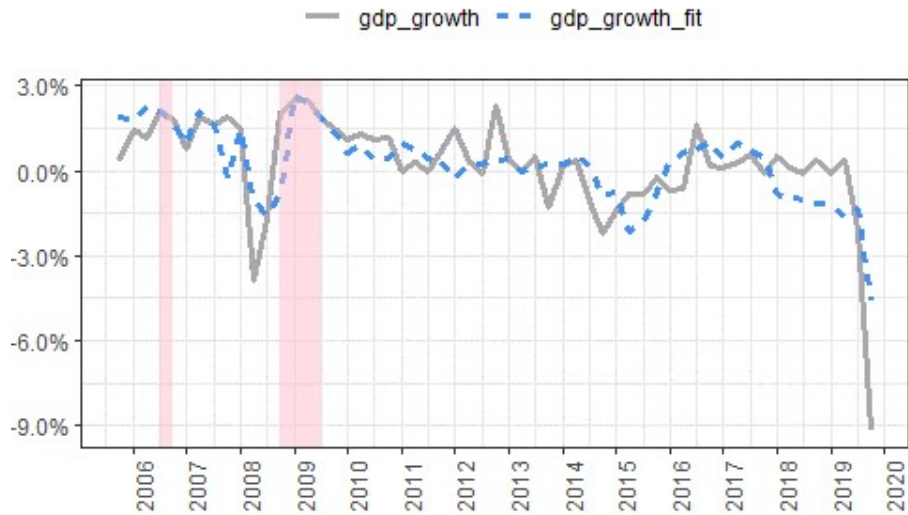


In the graph, the shaded section corresponds to the periods of high regime.

(b) Bolivia- Threshold value = 1,11%

Brasil, threshold variable: GDP growth

Threshold value: 1.7%

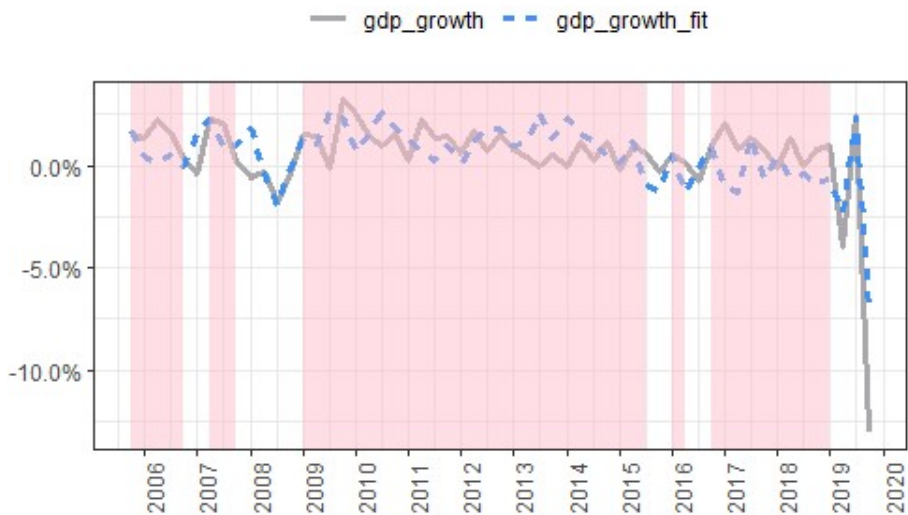


In the graph, the shaded section corresponds to the periods of high regime.

(a) Brazil - Threshold value = 1,7%

Chile, threshold variable: GDP growth

Threshold value: -0.2%

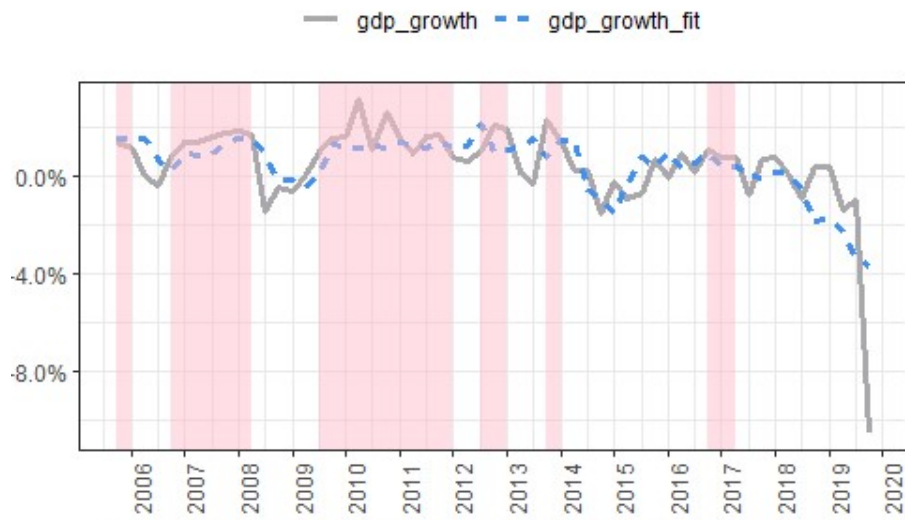


In the graph, the shaded section corresponds to the periods of high regime.

(b) Chile - Threshold value = -0,2%

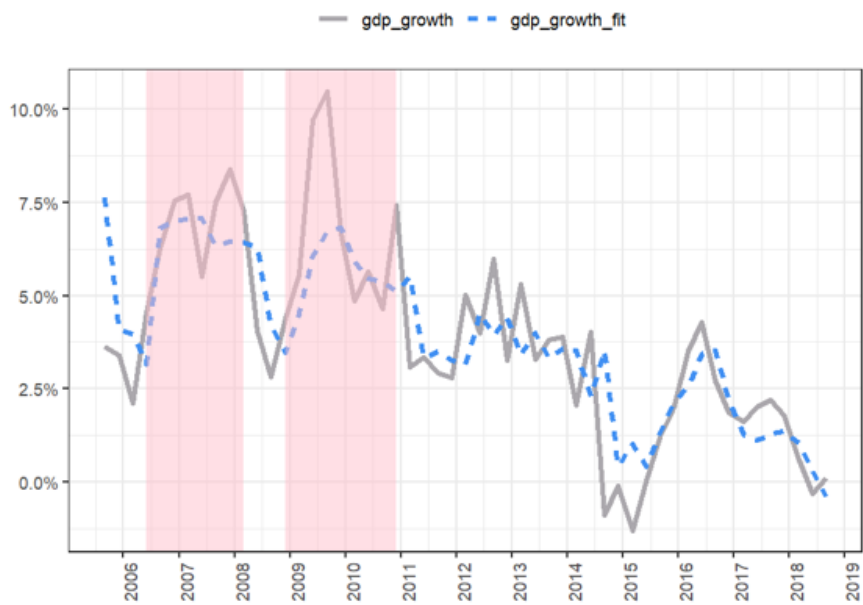
Ecuador, threshold variable: GDP growth

Threshold value: 0.74%



In the graph, the shaded section corresponds to the periods of high regime.

(a) Ecuador - Threshold value = -0,34%

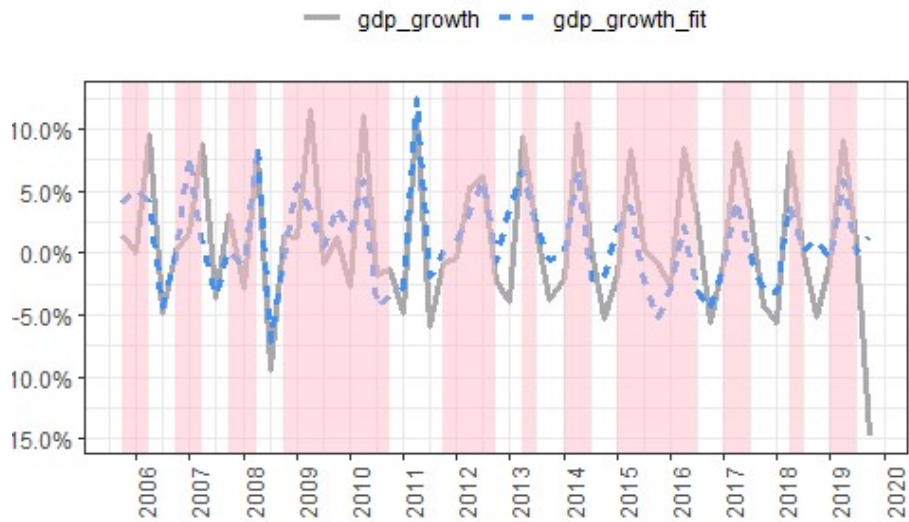


In the graph, the shaded section corresponds to the periods of high regime.

(b) Uruguay - Threshold value = 4,39%

Paraguay, threshold variable: GDP growth

Threshold value: -2.8%

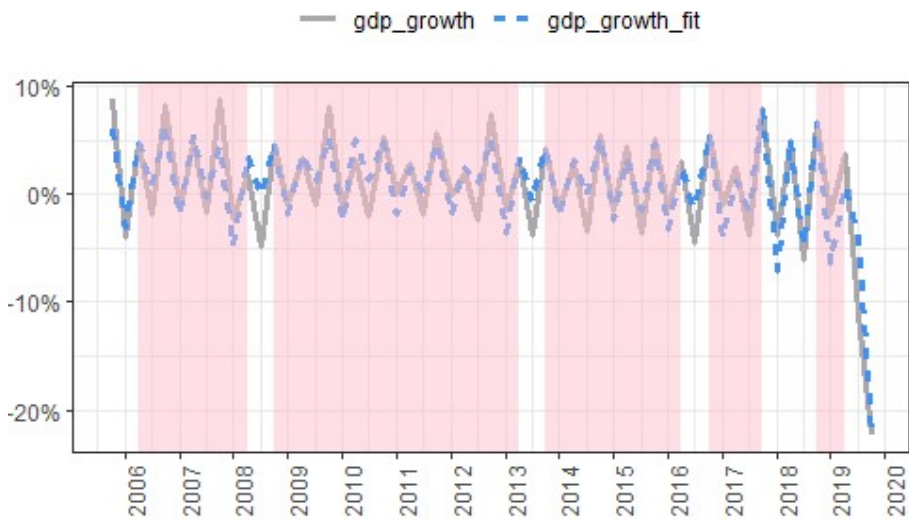


In the graph, the shaded section corresponds to the periods of high regime.

(a) Paraguay - Threshold value = -2,8%

Perú, threshold variable: GDP growth

Threshold value: -3.74%



In the graph, the shaded section corresponds to the periods of high regime.

(b) Peru - Threshold value = -4,39%

Table C.1.2. TVAR Estimate - Threshold Variable of Inflation Regime
Using Liquid assets to Short term liabilities (%) as Liquidity impact

Country	Variable	Low regime	P-value Low regime	High regime	P-value High regime
Argentina	Intercept	19,46	0,10	240,97	0,00
Argentina	gdp_growth -1	0,11	0,52	-1,09	0,01
Argentina	inflation -1	-4,37	0,33	-54,47	0,00
Argentina	liquid_assets_to_short_term_liabilities -1	0,45	0,02	-1,00	0,01
Argentina	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,63	0,02	2,09	0,00
Argentina	nominal_exchange_rate -1	0,01	0,99	-0,03	0,92
Argentina	nominal_interest_rate -1	28,16	0,16	110,33	0,00
Argentina	m2_to_gdp -1	0,04	0,99	9,04	0,00
Bolivia	Intercept	-225,88	0,67	-3,86	0,98
Bolivia	gdp_growth -1	-0,01	0,95	0,10	0,05
Bolivia	inflation -1	133,21	0,24	9,25	0,59
Bolivia	liquid_assets_to_short_term_liabilities -1	0,17	0,22	0,78	0,00
Bolivia	bank_liquid_reserves_to_bank_assets_ratio_percent -1	-1,72	0,00	0,26	0,06
Bolivia	nominal_exchange_rate -1	-28,89	0,04	-4,25	0,85
Bolivia	nominal_interest_rate -1	250,72	0,00	-148,18	0,10
Bolivia	m2_to_gdp -1	-4714,95	0,28	-81,15	0,85
Brazil	Intercept	4572,65	0,11	256,56	0,06
Brazil	gdp_growth -1	-9,03	0,12	1,56	0,56
Brazil	inflation -1	-1031,29	0,13	-50,67	0,11
Brazil	liquid_assets_to_short_term_liabilities -1	-0,09	0,82	0,37	0,02
Brazil	bank_liquid_reserves_to_bank_assets_ratio_percent -1	6,62	0,06	4,74	0,00
Brazil	nominal_exchange_rate -1	-0,99	0,98	13,29	0,05
Brazil	nominal_interest_rate -1	1182,45	0,32	-634,52	0,12
Brazil	m2_to_gdp -1	-23,85	0,69	-1,44	0,69
Chile	Intercept	241,95	0,02	72,91	0,10
Chile	gdp_growth -1	-0,53	0,08	-0,10	0,58
Chile	inflation -1	-52,97	0,04	-14,45	0,18
Chile	liquid_assets_to_short_term_liabilities -1	-0,20	0,27	0,20	0,34
Chile	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,75	0,03	0,18	0,21

Table C.1.2. TVAR Estimate - Threshold Variable of Inflation Regime
Using Liquid assets to Short term liabilities (%) as Liquidity impact

Country	Variable	Low regime	P-value Low regime	High regime	P-value High regime
Chile	nominal_exchange_rate -1	0,00	0,99	0,00	0,24
Chile	nominal_interest_rate -1	-22,06	0,23	-8,91	0,51
Chile	m2_to_gdp -1	0,00	0,82	0,00	0,39
Colombia	Intercept	-139,07	0,01	-0,07	1,00
Colombia	gdp_growth -1	0,05	0,91	-0,21	0,73
Colombia	inflation -1	36,75	0,01	10,83	0,49
Colombia	liquid_assets_to_short_term_liabilities -1	0,53	0,00	0,06	0,88
Colombia	bank_liquid_reserves_to_bank_assets_ratio_percent -1	1,24	0,08	-2,15	0,46
Colombia	nominal_exchange_rate -1	0,00	0,11	0,00	0,34
Colombia	nominal_interest_rate -1	-17,65	0,49	-68,54	0,42
Colombia	m2_to_gdp -1	-0,01	0,02	0,00	0,93
Ecuador	Intercept	982,97	0,00	150,30	0,05
Ecuador	gdp_growth -1	-0,34	0,90	0,36	0,40
Ecuador	inflation -1	-230,34	0,00	-32,11	0,07
Ecuador	liquid_assets_to_short_term_liabilities -1	0,37	0,24	0,35	0,01
Ecuador	bank_liquid_reserves_to_bank_assets_ratio_percent -1	13,88	0,01	0,62	0,01
Ecuador	nominal_interest_rate -1	-655,75	0,07	261,10	0,02
Ecuador	m2_to_gdp -1	-10672,01	0,27	284,37	0,91
Paraguay	Intercept	-668,47	0,03	107,90	0,14
Paraguay	gdp_growth -1	-0,08	0,69	-0,13	0,15
Paraguay	inflation -1	136,52	0,12	-24,29	0,21
Paraguay	liquid_assets_to_short_term_liabilities -1	-0,29	0,53	0,56	0,00
Paraguay	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,60	0,09	-0,10	0,69
Paraguay	nominal_exchange_rate -1	0,01	0,03	0,00	0,36
Paraguay	nominal_interest_rate -1	35,94	0,66	57,25	0,12
Paraguay	m2_to_gdp -1	94,68	0,54	5,51	0,77
Perú	Intercept	-253,99	0,01	49,91	0,83
Perú	gdp_growth -1	-0,01	0,87	0,17	0,21
Perú	inflation -1	64,34	0,00	-7,03	0,89

Table C.1.2. TVAR Estimate - Threshold Variable of Inflation Regime
Using Liquid assets to Short term liabilities (%) as Liquidity impact

Country	Variable	Low regime	P-value Low regime	High regime	P-value High regime
Perú	liquid_assets_to_short_term_liabilities -1	0,74	0,00	0,43	0,40
Perú	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,18	0,11	0,06	0,79
Perú	nominal_exchange_rate -1	-8,02	0,05	-2,39	0,70
Perú	nominal_interest_rate -1	-151,35	0,13	171,97	0,60
Perú	m2_to_gdp -1	-17,33	0,02	5,02	0,71
Uruguay	Intercept	286,48	0,00	-5,41	0,86
Uruguay	gdp_growth -1	-0,42	0,33	0,58	0,00
Uruguay	inflation -1	-53,24	0,02	0,01	1,00
Uruguay	liquid_assets_to_short_term_liabilities -1	0,03	0,83	0,88	0,00
Uruguay	bank_liquid_reserves_to_bank_assets_ratio_percent -1	1,16	0,02	0,13	0,11
Uruguay	nominal_exchange_rate -1	-1,84	0,01	0,17	0,27
Uruguay	nominal_interest_rate -1	-157,19	0,17	-28,11	0,61
Uruguay	m2_to_gdp -1	18253,12	0,36	1834,09	0,71
Venezuela	Intercept	19,50	0,21	65,66	0,12
Venezuela	gdp_growth -1	-0,02	0,55	0,03	0,50
Venezuela	inflation -1	1,60	0,62	-4,41	0,00
Venezuela	liquid_assets_to_short_term_liabilities -1	0,60	0,01	1,04	0,00
Venezuela	bank_liquid_reserves_to_bank_assets_ratio_percent -1	-0,07	0,28	-1,40	0,07
Venezuela	nominal_exchange_rate -1	-0,15	0,84	0,00	0,00
Venezuela	nominal_interest_rate -1	-75,59	0,01	206,36	0,00
Venezuela	m2_to_gdp -1	-0,96	0,26	0,00	0,00

Table C.1.3. TVAR Estimate - Threshold Variable of GDP growth Regime
Using Liquid assets to Short term liabilities (%) as Liquidity impact

Country	Variable	Low regime	P-value Low regime	High regime	P-value High regime
Argentina	Intercept	14,56	0,25	17,12	0,22
Argentina	gdp_growth -1	0,13	0,57	0,79	0,06
Argentina	inflation -1	-1,19	0,80	-0,41	0,94
Argentina	liquid_assets_to_short_term_liabilities -1	0,06	0,78	0,47	0,03
Argentina	bank_liquid_reserves_to_bank_assets_ratio_percent -1	1,09	0,01	0,17	0,60
Argentina	nominal_exchange_rate -1	0,08	0,53	0,23	0,72
Argentina	nominal_interest_rate -1	2,52	0,85	23,42	0,33
Argentina	m2_to_gdp -1	1,03	0,59	-2,15	0,61
Bolivia	Intercept	338,90	0,05	452,19	0,02
Bolivia	gdp_growth -1	0,50	0,00	0,00	1,00
Bolivia	inflation -1	-43,76	0,08	-61,25	0,02
Bolivia	liquid_assets_to_short_term_liabilities -1	0,67	0,00	0,72	0,00
Bolivia	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,04	0,83	-0,06	0,73
Bolivia	nominal_exchange_rate -1	-19,45	0,04	-25,35	0,01
Bolivia	nominal_interest_rate -1	190,61	0,00	162,92	0,01
Bolivia	m2_to_gdp -1	998,26	0,15	1299,97	0,07
Brazil	Intercept	184,20	0,18	-9440,22	0,01
Brazil	gdp_growth -1	-2,46	0,34	5,61	0,83
Brazil	inflation -1	-43,02	0,19	2099,51	0,02
Brazil	liquid_assets_to_short_term_liabilities -1	0,85	0,00	0,35	0,50
Brazil	bank_liquid_reserves_to_bank_assets_ratio_percent -1	1,58	0,16	44,30	0,01
Brazil	nominal_exchange_rate -1	9,13	0,23	-153,61	0,20
Brazil	nominal_interest_rate -1	-68,67	0,86	734,69	0,88
Brazil	m2_to_gdp -1	-1,73	0,66	-197,64	0,22
Chile	Intercept	87,90	0,01	325,13	0,02
Chile	gdp_growth -1	0,18	0,37	1,10	0,12
Chile	inflation -1	-18,59	0,04	-79,37	0,03
Chile	liquid_assets_to_short_term_liabilities -1	0,17	0,10	0,96	0,01
Chile	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,17	0,12	0,59	0,12

Table C.1.3. TVAR Estimate - Threshold Variable of GDP growth Regime
Using Liquid assets to Short term liabilities (%) as Liquidity impact

Country	Variable	Low regime	P-value Low regime	High regime	P-value High regime
Chile	nominal_exchange_rate -1	0,01	0,06	-0,04	0,03
Chile	nominal_interest_rate -1	5,31	0,55	-40,56	0,11
Chile	m2_to_gdp -1	0,00	0,16	0,02	0,02
Colombia	Intercept				
Colombia	gdp_growth -1				
Colombia	inflation -1				
Colombia	liquid_assets_to_short_term_liabilities -1				
Colombia	bank_liquid_reserves_to_bank_assets_ratio_percent -1				
Colombia	nominal_exchange_rate -1				
Colombia	nominal_interest_rate -1				
Colombia	m2_to_gdp -1				
Ecuador	Intercept	68,52	0,39	-8,62	0,94
Ecuador	gdp_growth -1	-0,04	0,96	-0,16	0,87
Ecuador	inflation -1	-16,59	0,38	6,67	0,81
Ecuador	liquid_assets_to_short_term_liabilities -1	0,64	0,00	0,36	0,10
Ecuador	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,59	0,10	-0,02	0,97
Ecuador	nominal_interest_rate -1	257,95	0,10	140,33	0,31
Ecuador	m2_to_gdp -1	696,51	0,83	-3351,32	0,52
Paraguay	Intercept	393,20	0,31	-22,95	0,78
Paraguay	gdp_growth -1	-1,72	0,15	-0,01	0,94
Paraguay	inflation -1	-92,94	0,35	9,87	0,63
Paraguay	liquid_assets_to_short_term_liabilities -1	0,44	0,17	0,69	0,00
Paraguay	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,17	0,70	-0,42	0,04
Paraguay	nominal_exchange_rate -1	-0,01	0,05	0,00	0,10
Paraguay	nominal_interest_rate -1	-121,32	0,37	91,37	0,02
Paraguay	m2_to_gdp -1	90,84	0,31	-29,68	0,12
Perú	Intercept	-133,09	0,09	-115,75	0,18
Perú	gdp_growth -1	-0,03	0,90	-0,58	0,01
Perú	inflation -1	38,51	0,05	34,73	0,10

Table C.1.3. TVAR Estimate - Threshold Variable of GDP growth Regime
Using Liquid assets to Short term liabilities (%) as Liquidity impact

Country	Variable	Low regime	P-value Low regime	High regime	P-value High regime
Perú	liquid_assets_to_short_term_liabilities -1	0,64	0,00	0,81	0,00
Perú	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,05	0,59	-0,07	0,49
Perú	nominal_exchange_rate -1	-6,98	0,02	-6,01	0,07
Perú	nominal_interest_rate -1	-232,69	0,02	-138,02	0,20
Perú	m2_to_gdp -1	-10,05	0,16	-12,73	0,11
Uruguay	Intercept	-70,81	0,75	11,45	0,82
Uruguay	gdp_growth -1	0,10	0,95	0,21	0,38
Uruguay	inflation -1	15,53	0,76	0,05	1,00
Uruguay	liquid_assets_to_short_term_liabilities -1	0,75	0,00	0,73	0,00
Uruguay	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,29	0,77	0,10	0,35
Uruguay	nominal_exchange_rate -1	-0,30	0,72	0,00	0,99
Uruguay	nominal_interest_rate -1	-27,35	0,82	-171,28	0,03
Uruguay	m2_to_gdp -1	2735,03	0,91	4909,17	0,56
Venezuela	Intercept	7,36	0,48	5,46	0,55
Venezuela	gdp_growth -1	-0,28	0,08	-0,04	0,82
Venezuela	inflation -1	-0,43	0,57	-0,25	0,60
Venezuela	liquid_assets_to_short_term_liabilities -1	0,94	0,00	1,06	0,00
Venezuela	bank_liquid_reserves_to_bank_assets_ratio_percent -1	-0,08	0,38	-0,10	0,40
Venezuela	nominal_exchange_rate -1	0,00	0,89	0,00	0,25
Venezuela	nominal_interest_rate -1	-26,23	0,61	-5,13	0,86
Venezuela	m2_to_gdp -1	0,00	0,93	0,00	0,65

Table C.1.4. TVAR Estimate - Thershold Variable of Inflation Regime
Using M2 to GDP (%) as Monetary impact

Country	Variable	Low regime	P-value Low regime	High regime	P-value High regime
Argentina	Intercept	-1,65	0,01	-1,59	0,53
Argentina	gdp_growth -1	0,01	0,33	-0,18	0,00
Argentina	inflation -1	0,68	0,01	1,49	0,01
Argentina	liquid_assets_to_short_term_liabilities -1	-0,01	0,32	-0,04	0,07
Argentina	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,00	0,91	-0,02	0,45
Argentina	nominal_exchange_rate -1	0,00	0,92	-0,07	0,00
Argentina	nominal_interest_rate -1	0,20	0,85	2,39	0,08
Argentina	m2_to_gdp -1	0,69	0,00	0,44	0,00
Bolivia	Intercept	0,04	0,84	-0,12	0,15
Bolivia	gdp_growth -1	0,00	0,61	0,00	0,05
Bolivia	inflation -1	-0,01	0,85	0,02	0,00
Bolivia	liquid_assets_to_short_term_liabilities -1	0,00	0,93	0,00	0,02
Bolivia	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,00	0,87	0,00	0,07
Bolivia	nominal_exchange_rate -1	0,00	0,86	0,00	0,75
Bolivia	nominal_interest_rate -1	-0,02	0,62	-0,04	0,26
Bolivia	m2_to_gdp -1	1,19	0,47	0,51	0,00
Brazil	Intercept	-51,26	0,54	-0,33	0,93
Brazil	gdp_growth -1	-0,02	0,92	0,08	0,34
Brazil	inflation -1	12,29	0,54	0,11	0,90
Brazil	liquid_assets_to_short_term_liabilities -1	0,00	0,81	0,00	0,82
Brazil	bank_liquid_reserves_to_bank_assets_ratio_percent -1	-0,02	0,87	-0,01	0,84
Brazil	nominal_exchange_rate -1	0,00	1,00	0,30	0,12
Brazil	nominal_interest_rate -1	22,80	0,52	-6,66	0,57
Brazil	m2_to_gdp -1	-0,04	0,98	0,92	0,00
Chile	Intercept	-17811,39	0,09	-33644,32	0,00
Chile	gdp_growth -1	-5,14	0,87	36,59	0,07
Chile	inflation -1	4676,78	0,08	8529,01	0,00
Chile	liquid_assets_to_short_term_liabilities -1	7,72	0,68	-20,34	0,35
Chile	bank_liquid_reserves_to_bank_assets_ratio_percent -1	-34,78	0,31	-20,52	0,18

Table C.1.4. TVAR Estimate - Threshold Variable of Inflation Regime
Using M2 to GDP (%) as Monetary impact

Country	Variable	Low regime	P-value Low regime	High regime	P-value High regime
Chile	nominal_exchange_rate -1	0,29	0,78	-0,64	0,06
Chile	nominal_interest_rate -1	-534,39	0,78	3699,23	0,01
Chile	m2_to_gdp -1	-0,19	0,76	-0,37	0,03
Colombia	Intercept	-10323,50	0,00	-5480,23	0,21
Colombia	gdp_growth -1	-9,75	0,72	-13,58	0,71
Colombia	inflation -1	2700,00	0,00	1215,84	0,21
Colombia	liquid_assets_to_short_term_liabilities -1	-0,85	0,89	46,90	0,04
Colombia	bank_liquid_reserves_to_bank_assets_ratio_percent -1	-71,28	0,10	-63,36	0,72
Colombia	nominal_exchange_rate -1	0,12	0,23	0,28	0,09
Colombia	nominal_interest_rate -1	1546,88	0,33	-1940,99	0,71
Colombia	m2_to_gdp -1	0,21	0,40	-0,15	0,58
Ecuador	Intercept	0,00	0,89	0,00	0,79
Ecuador	gdp_growth -1	0,00	0,47	0,00	0,06
Ecuador	inflation -1	0,00	0,96	0,00	0,76
Ecuador	liquid_assets_to_short_term_liabilities -1	0,00	0,01	0,00	0,19
Ecuador	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,00	0,04	0,00	0,43
Ecuador	nominal_interest_rate -1	-0,01	0,43	0,01	0,05
Ecuador	m2_to_gdp -1	-0,17	0,51	0,99	0,00
Paraguay	Intercept	-2,18	0,31	-1,91	0,00
Paraguay	gdp_growth -1	0,00	0,73	0,00	0,03
Paraguay	inflation -1	0,72	0,24	0,52	0,00
Paraguay	liquid_assets_to_short_term_liabilities -1	0,01	0,11	0,00	0,26
Paraguay	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,00	0,36	0,00	0,64
Paraguay	nominal_exchange_rate -1	0,00	0,30	0,00	0,70
Paraguay	nominal_interest_rate -1	-0,37	0,52	0,27	0,30
Paraguay	m2_to_gdp -1	-0,68	0,53	0,49	0,00
Perú	Intercept	-6,36	0,00	3,85	0,45
Perú	gdp_growth -1	0,00	0,06	0,01	0,01
Perú	inflation -1	1,49	0,00	-0,47	0,67

Table C.1.4. TVAR Estimate - Threshold Variable of Inflation Regime
Using M2 to GDP (%) as Monetary impact

Country	Variable	Low regime	P-value Low regime	High regime	P-value High regime
Perú	liquid_assets_to_short_term_liabilities -1	0,00	0,40	-0,01	0,63
Perú	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,01	0,01	-0,02	0,01
Perú	nominal_exchange_rate -1	-0,16	0,07	-0,14	0,31
Perú	nominal_interest_rate -1	2,81	0,20	15,15	0,04
Perú	m2_to_gdp -1	0,44	0,01	0,38	0,20
Uruguay	Intercept	0,00	0,87	0,00	0,00
Uruguay	gdp_growth -1	0,00	0,33	0,00	0,42
Uruguay	inflation -1	0,00	0,96	0,00	0,01
Uruguay	liquid_assets_to_short_term_liabilities -1	0,00	0,97	0,00	0,03
Uruguay	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,00	0,24	0,00	0,63
Uruguay	nominal_exchange_rate -1	0,00	0,64	0,00	0,42
Uruguay	nominal_interest_rate -1	0,00	0,76	0,00	0,20
Uruguay	m2_to_gdp -1	-0,10	0,88	0,49	0,01
Venezuela	Intercept	-1,84	1,00	-3045138,67	0,04
Venezuela	gdp_growth -1	0,01	1,00	205,11	0,88
Venezuela	inflation -1	0,53	1,00	-1041,91	0,98
Venezuela	liquid_assets_to_short_term_liabilities -1	-0,01	1,00	5559,93	0,09
Venezuela	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,01	1,00	28003,60	0,29
Venezuela	nominal_exchange_rate -1	-0,14	1,00	6,39	0,00
Venezuela	nominal_interest_rate -1	-3,33	1,00	10637578,20	0,00
Venezuela	m2_to_gdp -1	1,08	1,00	1,01	0,00

Table C.1.5. TVAR Estimate - Threshold Variable of GDP growth Regime
Using M2 to GDP (%) as Monetary impact

Country	Variable	Low regime	P-value Low regime	High regime	P-value High regime
Argentina	Intercept	-6,74	0,00	-1,43	0,22
Argentina	gdp_growth -1	-0,05	0,01	0,02	0,65
Argentina	inflation -1	2,46	0,00	0,88	0,05
Argentina	liquid_assets_to_short_term_liabilities -1	0,01	0,54	-0,03	0,10
Argentina	bank_liquid_reserves_to_bank_assets_ratio_percent -1	-0,05	0,11	-0,01	0,84
Argentina	nominal_exchange_rate -1	-0,04	0,00	0,04	0,47
Argentina	nominal_interest_rate -1	-2,34	0,05	0,10	0,96
Argentina	m2_to_gdp -1	0,24	0,15	0,46	0,19
Bolivia	Intercept	-0,02	0,75	-0,12	0,02
Bolivia	gdp_growth -1	0,00	0,00	0,00	0,14
Bolivia	inflation -1	0,00	0,87	0,02	0,02
Bolivia	liquid_assets_to_short_term_liabilities -1	0,00	0,59	0,00	0,02
Bolivia	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,00	0,46	0,00	0,01
Bolivia	nominal_exchange_rate -1	0,00	0,61	0,01	0,02
Bolivia	nominal_interest_rate -1	-0,01	0,67	-0,04	0,01
Bolivia	m2_to_gdp -1	0,99	0,00	0,61	0,00
Brazil	Intercept	4,38	0,21	-8,43	0,93
Brazil	gdp_growth -1	0,11	0,11	0,14	0,83
Brazil	inflation -1	-1,03	0,21	3,22	0,88
Brazil	liquid_assets_to_short_term_liabilities -1	0,00	0,66	0,00	0,96
Brazil	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,01	0,71	0,05	0,89
Brazil	nominal_exchange_rate -1	0,46	0,02	1,07	0,72
Brazil	nominal_interest_rate -1	-8,28	0,41	-52,97	0,66
Brazil	m2_to_gdp -1	0,92	0,00	-0,53	0,89
Chile	Intercept	-18886,52	0,00	-15202,49	0,29
Chile	gdp_growth -1	47,48	0,03	-15,49	0,83
Chile	inflation -1	4815,46	0,00	3822,76	0,30
Chile	liquid_assets_to_short_term_liabilities -1	10,98	0,31	54,92	0,14
Chile	bank_liquid_reserves_to_bank_assets_ratio_percent -1	-33,87	0,01	-35,04	0,37

Table C.1.5. TVAR Estimate - Threshold Variable of GDP growth Regime
Using M2 to GDP (%) as Monetary impact

Country	Variable	Low regime	P-value Low regime	High regime	P-value High regime
Chile	nominal_exchange_rate -1	0,33	0,30	-1,50	0,44
Chile	nominal_interest_rate -1	-715,12	0,45	2224,13	0,40
Chile	m2_to_gdp -1	0,02	0,90	0,32	0,68
Ecuador	Intercept	0,00	0,88	0,00	0,30
Ecuador	gdp_growth -1	0,00	0,31	0,00	0,30
Ecuador	inflation -1	0,00	0,88	0,00	0,23
Ecuador	liquid_assets_to_short_term_liabilities -1	0,00	0,44	0,00	0,01
Ecuador	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,00	0,46	0,00	0,10
Ecuador	nominal_interest_rate -1	0,00	0,35	0,01	0,05
Ecuador	m2_to_gdp -1	0,96	0,00	0,82	0,00
Paraguay	Intercept	-1,76	0,44	-1,79	0,00
Paraguay	gdp_growth -1	0,01	0,23	0,00	0,03
Paraguay	inflation -1	0,41	0,48	0,48	0,00
Paraguay	liquid_assets_to_short_term_liabilities -1	0,00	0,11	0,00	0,42
Paraguay	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,00	0,70	0,00	0,52
Paraguay	nominal_exchange_rate -1	0,00	0,37	0,00	0,77
Paraguay	nominal_interest_rate -1	0,16	0,84	0,15	0,51
Paraguay	m2_to_gdp -1	0,71	0,17	0,53	0,00
Perú	Intercept	-3,43	0,12	-1,48	0,54
Perú	gdp_growth -1	0,01	0,34	0,00	0,45
Perú	inflation -1	0,84	0,13	0,48	0,43
Perú	liquid_assets_to_short_term_liabilities -1	0,00	0,69	0,00	0,44
Perú	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,00	0,73	0,00	0,19
Perú	nominal_exchange_rate -1	-0,08	0,38	-0,05	0,58
Perú	nominal_interest_rate -1	-0,01	1,00	-3,06	0,32
Perú	m2_to_gdp -1	0,72	0,00	0,80	0,00
Uruguay	Intercept	-0,01	0,00	0,00	0,02
Uruguay	gdp_growth -1	0,00	0,21	0,00	0,67
Uruguay	inflation -1	0,00	0,00	0,00	0,02

Table C.1.5. TVAR Estimate - Threshold Variable of GDP growth Regime
Using M2 to GDP (%) as Monetary impact

Country	Variable	Low regime	P-value Low regime	High regime	P-value High regime
Uruguay	liquid_assets_to_short_term_liabilities -1	0,00	0,21	0,00	0,91
Uruguay	bank_liquid_reserves_to_bank_assets_ratio_percent -1	0,00	0,59	0,00	0,42
Uruguay	nominal_exchange_rate -1	0,00	0,78	0,00	0,76
Uruguay	nominal_interest_rate -1	0,00	0,64	0,00	0,73
Uruguay	m2_to_gdp -1	-0,54	0,22	0,60	0,00
Venezuela	Intercept	13969,88	0,88	479,89	1,00
Venezuela	gdp_growth -1	883,58	0,54	0,80	1,00
Venezuela	inflation -1	-37633,74	0,00	409,90	0,93
Venezuela	liquid_assets_to_short_term_liabilities -1	3903,42	0,00	-28,18	0,97
Venezuela	bank_liquid_reserves_to_bank_assets_ratio_percent -1	-1090,47	0,18	-5,14	1,00
Venezuela	nominal_exchange_rate -1	5,97	0,00	1,82	0,00
Venezuela	nominal_interest_rate -1	976804,42	0,05	-11587,89	0,97
Venezuela	m2_to_gdp -1	2,59	0,00	0,69	0,00

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